

U.S. Mine Bureau
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
JOSEPH A. HOLMES, DIRECTOR

THE HUMIDITY OF MINE AIR

WITH ESPECIAL REFERENCE TO COAL MINES
IN ILLINOIS

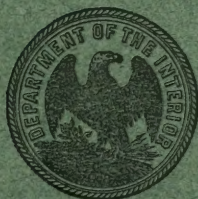
BY

R. Y. WILLIAMS

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ENGINE STORAGE
ILLINOIS COAL-MINING INVESTIGATIONS
COOPERATIVE AGREEMENT

[This report was prepared under a cooperative agreement with the
Illinois State Geological Survey and the department of mining
engineering of the University of Illinois]



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THE HUMIDITY OF MINE AIR.

By R. Y. WILLIAMS.

INTRODUCTION.

The investigative work described in this report was undertaken by the Bureau of Mines under a cooperative agreement with the department of mining engineering of the University of Illinois and the Illinois State Geological Survey.^a The purpose of this agreement was to provide for a comprehensive investigation of coal-mining conditions in the State, with especial reference to the possibility of lessening waste in the mining and preparation of coal and of reducing the dangers to which miners are exposed. The Bureau of Mines paid particular attention to those phases of the investigation that were of general interest from their bearing on safety and efficiency in the coal-mining industry as a whole. Thus, it studied the occurrence of gas (methane) in the mines of the southern part of the State,^b tested the inflammability of the coal dust from many mines, examined the efficiency of the control of ventilating currents, and investigated the factors affecting the humidity of mine air with respect to their bearing on the occurrence of mine explosions.

Following the establishment of the fact that under certain conditions dry bituminous coal dust is inflammable, there arose the problem of finding efficient methods of preventing or limiting coal-dust explosions.

Experiments in the gas-and-dust gallery at the Pittsburgh testing station of the Bureau of Mines verified the fact that certain dusts that explode violently when dry are rendered inert by proper humidification of the atmosphere within the gallery, and the importance of humidity as a factor in limiting the inflammability of coal dust in a mine is demonstrated by the fact that there has never been in Illinois a dust explosion during the summer months, whereas the records show a number of dust explosions during cold weather. It is easy to see that the warm moisture-laden air that enters a mine in the summer must deposit moisture on cooling, whereas the cold and relatively dry air that enters in winter must take up moisture as it becomes heated in traveling through the mine.

^a For a detailed account of the terms of this agreement, see Preliminary report on organization and method of investigations: Illinois Coal-Mining Investigations, Cooperative Agreement, 1913, 71 pp.

^b Darton, N. H., Occurrence of explosive gases in coal mines: Bull. 72, Bureau of Mines, 1914. In press.

A study of humidity in the coal mines of the State was begun in January, 1912, by the Illinois coal-mining investigations previously mentioned, in cooperation with the United States Weather Bureau and the operators of 20 typical mines in the State. In this study records were made that show the humidity changes both underground and on the surface during the seasonal changes of a complete year. These records afford a basis for generalizations as to humidity. The records, with pertinent discussion, are presented in this report for the purpose of supplying information that will assist operators and miners in making mines safe from coal-dust explosions.

A separate report prepared in connection with the cooperative investigation will discuss the character of the coal dusts encountered in the different mining districts in Illinois, and which dusts are the most dangerous.

In the collection and compilation of the data presented on the following pages the author has received suggestions and helpful criticism from his associates, to whom, and especially to George S. Rice, chief mining engineer of the Bureau of Mines, and L. A. Scholl, jr., junior chemist, he hereby makes acknowledgment of his indebtedness. Thanks are due S. T. Wallage for the calculations necessary in preparing Table 6.

The work of Carl Scholz, H. N. Eavenson, and Frank Haas has been reviewed in pages 14 to 16. The author also wishes to express his indebtedness for the hearty cooperation of the United States Weather Bureau and the operators of the 20 selected mines.

FUNDAMENTAL CONSIDERATIONS.

DEFINITION OF TERMS.

To insure a clear understanding of the discussion and records in this report, definitions of certain terms used are presented below:

The temperature of mine air or of the outside atmosphere signifies the degree of sensible heat or cold.

Absolute humidity signifies the total quantity of water vapor present in a given volume of air.

Relative humidity is the ratio of the quantity of vapor present to the quantity necessary to saturate, at the given temperature and pressure, the space occupied by the air.

Dew point is that temperature of the air at which the water vapor present begins to condense into visible moisture—that is, the temperature of the air when the relative humidity is 100 per cent.

Evaporation is the transformation of water into aqueous vapor.

Latent heat of vaporization is the quantity of heat absorbed during evaporation. This quantity varies slightly with the temperature at which evaporation takes place.

The specific heat of a substance is the ratio of the heat required to raise the temperature of a certain weight of the substance 1 degree to that required to raise the temperature of the same weight of water 1 degree (from 62° to 63° F.).

A thermometer is an instrument for measuring temperature and is based on the fact that different substances expand, or contract, differently under the same changes in temperature. For example, mercury within a glass tube expands more on a rise of temperature than does the glass tube, and the difference of expansion is utilized as the measure of temperature. There are several scales or manners of graduating thermometers; but the one adopted in this report is the Fahrenheit, in which the freezing point of water is at 32° and the boiling point at 212°.

A thermograph is an instrument that automatically records variations in atmospheric temperature. An arm carrying a pen is connected with a spiral lamina that expands or contracts as the temperature rises or falls. The pen, fed with special ink, makes a mark on a chart that is revolved by clockwork. Each chart provides a record for one week.

A psychrometer or hygrometer is an instrument for measuring the quantity of aqueous vapor in the air. One type involves a determination of the temperature of evaporation and consists of two similar thermometers, one called the dry bulb and the other the wet bulb. A thin muslin sack is fitted over the wet-bulb thermometer, and in order to make an observation the sack is thoroughly moistened and both thermometers are placed in a current of air that has a velocity of 15 feet or more per second. If the relative humidity of the air is less than 100 per cent, some of the water on the muslin sack is evaporated, a certain amount of heat is absorbed by evaporation, and the temperature of the wet-bulb thermometer is reduced to a point at which the amount of heat absorbed by evaporation is just equal to that received from the surrounding air. From the readings of the two thermometers, by reference to suitable tables, the relative humidity and the quantity of aqueous vapor per cubic foot of the air may be determined.

There are two kinds of instruments using wet-bulb and dry-bulb thermometers for determining the relative humidity of air—the sling psychrometer and the stationary hygrometer.

The sling psychrometer is used in places where the velocity of the air is low. The instrument must be rapidly whirled through the air in order that the velocity against the wet-bulb thermometer shall approximate 15 feet per second. The standard sling psychrometer designed by the United States Weather Bureau has two thermometers mounted side by side, the wet-bulb thermometer extending

below the dry bulb, which are attached by a link to a handle. By means of the handle the instrument can be whirled to obtain a velocity of the wet bulb of about 3 feet per second. This type of psychrometer is unprotected, and when it is swung in a mine it is likely to be broken by striking against the side, roof, or a timber. To guard against such breakage the Bureau of Mines has designed a special form (Pl. I), in which the thermometers are attached to an aluminum frame, with a pivoted handle stiffly connected. Carried in a leather case with shoulder strap this is a convenient instrument for mine use, and if used with ordinary care it is not liable to be broken.

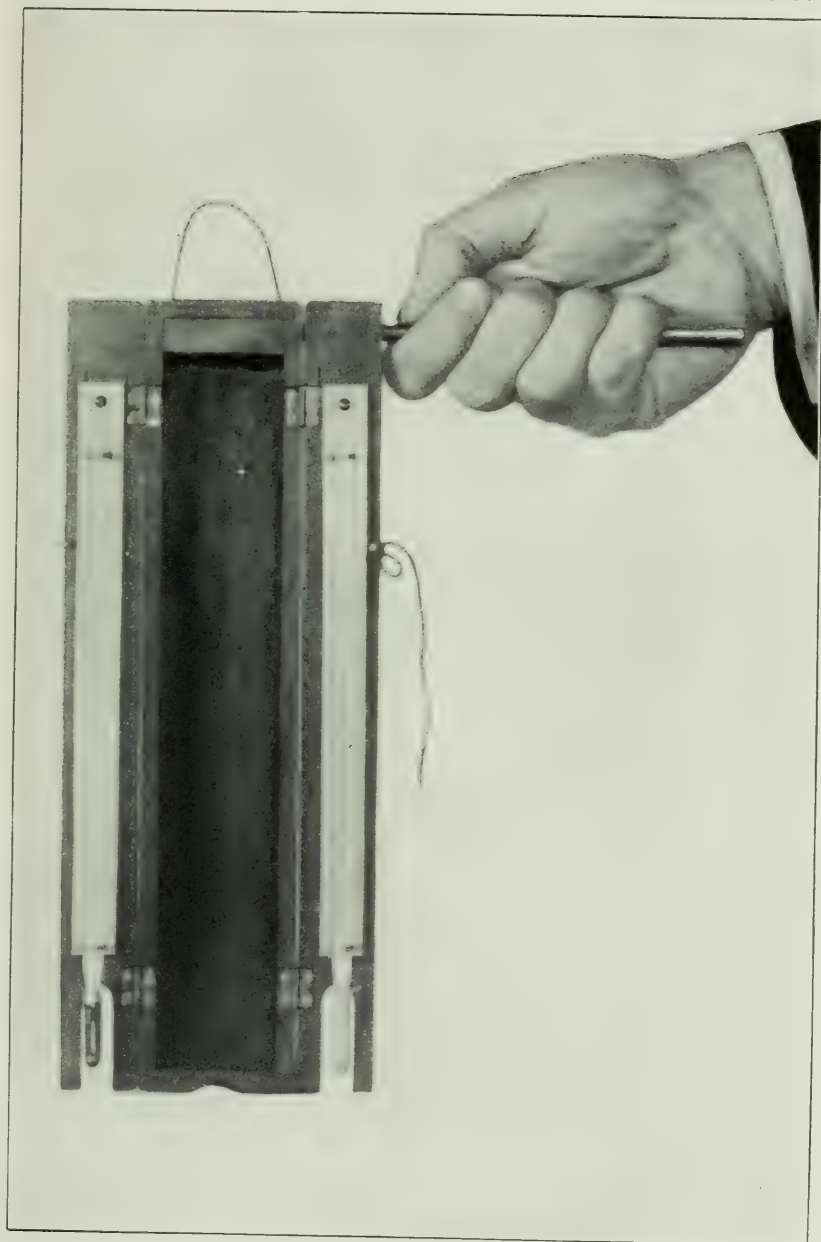
The stationary hygrometer may be used in places where the air is moving at the required velocity of 15 feet or more per second. This form of instrument was used in the cooperative investigations for the underground readings at the mines. The hygrometer (Pl. II) consists of two exposed thermometers 12 inches long, accurately calibrated and graduated to the Fahrenheit scale, and mounted on a silvered brass back which is fastened by a bent support to a wooden frame. The thermometer bulbs extend 2 inches below the mounting to allow free circulation of air around the bulbs and the stems. The wet bulb is covered with a fine muslin bag to which is attached the wicking that extends into a nicked water cup. Water is thus brought by capillary attraction to the muslin bag. In order to protect the hygrometers from breakage, a shelter (Pl. II) of 24-gage galvanized iron was made. It consisted of two 7-inch cylinders intersecting at right angles. To allow perfect circulation of air around the thermometer bulbs, the horizontal cylinder is open at both ends, each end being protected by a screen of hardware cloth of $\frac{1}{4}$ -inch mesh. In the vertical cylinder there is a similarly protected opening to allow convenient reading of the thermometers.

A hygrograph is an instrument by which the variations in atmospheric humidity are automatically recorded. In appearance, this instrument resembles a thermograph except that an animal hair is substituted for the spiral lamina. The hair expands and contracts with changes in relative humidity, and the movement is recorded on the revolving chart with a pen.

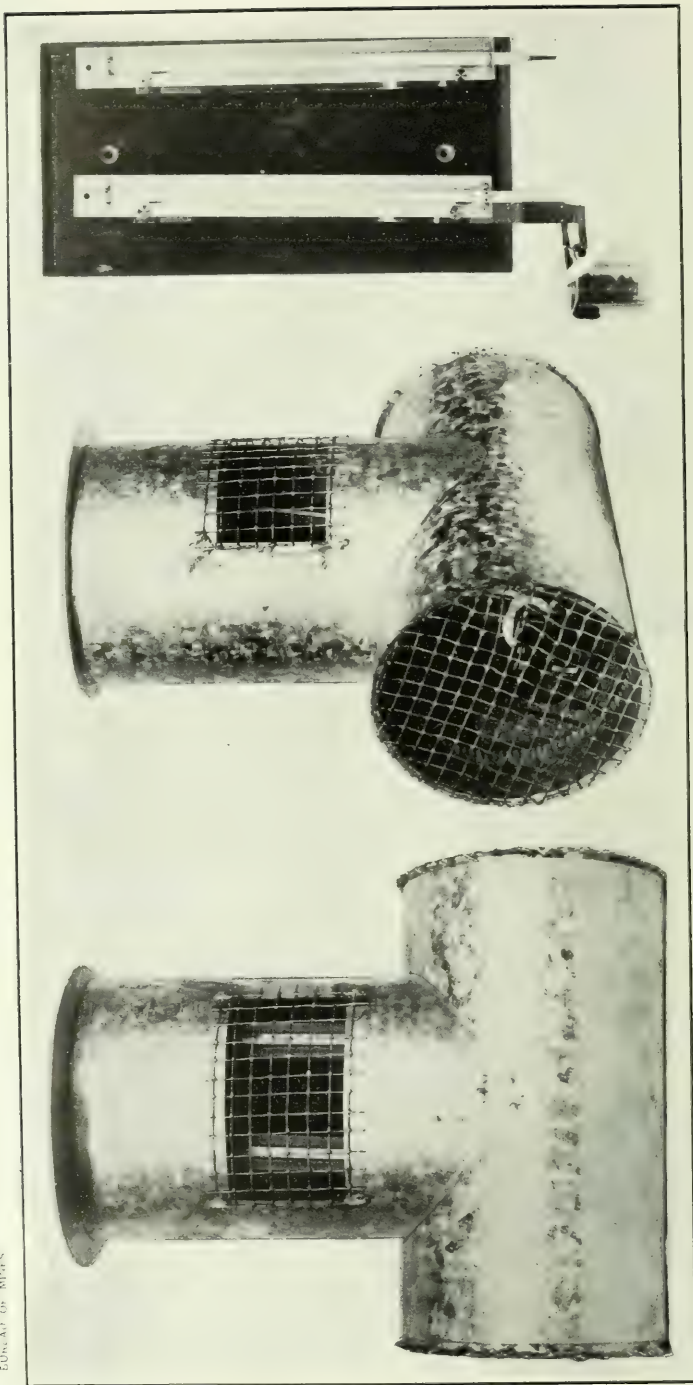
PHYSICAL LAWS CONTROLLING THE HUMIDITY OF MINE AIR.

THE KINETIC THEORY OF FLUIDS.

According to the kinetic theory, gases and liquids are composed of extremely small particles, called molecules. These particles dart about in straight lines until deflected by encounters with other molecules or with the walls of the containing vessel. The average velocity of the molecules increases with the temperature.



PSYCHROMETER DESIGNED BY BUREAU OF MINES.



MINE HYGROMETER AND TWO VIEWS OF HYGROMETER SHELTER

When liquid water and water vapor are in contact some of the darting molecules of the liquid escape from the surface of the liquid and enter the vapor. Also, some of the molecules of the vapor enter the liquid. The measure of the tendency of a substance to become a gas, or vapor, is its vapor pressure. Different substances have different vapor pressures, and these differences may be shown by the fall of the mercury column in a barometer tube when a small quantity of a liquid is inserted so that its vapor can enter the space above the mercury in the tube.

If the vapor pressure of the liquid be greater than the pressure of the vapor, more molecules leave the liquid than return to it, and evaporation takes place. If the vapor pressure of the liquid be less than that of the vapor, more molecules enter the liquid than leave it, and there is condensation.

For any given temperature there is a definite vapor pressure at which the number of molecules leaving the liquid equals the number of those entering it. This state is defined as physical equilibrium and is independent of the amounts, whether relative or absolute, of either the liquid or the vapor.

To illustrate the effects of varying the relative temperature and humidity of water and water vapor in juxtaposition, the following tabulation has been prepared:

TABLE 1.—*Effects of varying the relative temperature and humidity of water and water vapor in juxtaposition.*

Temperature of water.	Temperature of vapor.	Relative humidity of vapor.	Vapor pressure of water.	Pressure of vapor.	Result.
° F.	° F.	Per cent.	Inches of mercury.	Inches of mercury.	
60	30	100	.517	0.164	Evaporation.
60	60	60	.517	.310	Do.
60	90	85	.517	1.197	Condensation.
60	80	50.6	.517	.517	Neither evaporation nor condensation.

Table 2, below, gives the values of the vapor pressure of water, in inches of mercury, for temperatures ranging from 0° to 212° F.

TABLE 2.—*Vapor pressure of water for temperatures of 0° to 212° F.^a*

Temperature.	Vapor pressure of water.	Temperature.	Vapor pressure of water.
° F.	Inches of mercury.	° F.	Inches of mercury.
0	0.0353	70	.732
10	.0631	80	1.022
20	.103	90	1.408
30	.164	100	1.916
40	.247	150	7.552
50	.360	200	23.45
60	.517	212	29.92

^a Marvin, C. F., Psychrometric tables: U. S. Weather Bureau Bulletin 235. 1900.

RATE OF EVAPORATION AND CONDENSATION.

The rate of evaporation and the rate of condensation depend mainly on the difference between the pressure of the vapor and the vapor pressure of the liquid. Unfortunately, there are available no empirical data showing the quantity of water that will change to a unit volume of vapor under a given difference of pressure acting for a unit of time.

The following factors, however, determine in a relative way the rates of evaporation and of condensation, and even the minor factors assume importance in studies of mine air, because of the volume of the ventilating currents and the amount of moisture they carry.

Temperature.—The vapor pressure increases with temperature, hence temperature is the most important factor influencing the rates of evaporation and condensation.

Relative humidity.—The values for the vapor pressure of water given in Table 2 are correct only for a relative humidity of 100 per cent. For any other relative humidity the pressure of the vapor will vary directly with the percentage of saturation. For example, if the temperature is 60° F., and the relative humidity is 80 per cent, the pressure of the vapor will be 0.517 multiplied by 80 per cent, or 0.414 inches.

Volume.—The rate of evaporation is ordinarily independent of the amount, whether relative or absolute, of the water. When water particles are exceedingly small, however, as in exhaust steam, their surface area is great, and the rate of evaporation is correspondingly increased.

Absorption.—All coals absorb moisture. The quantity absorbed depends on the nature of the coal and on local conditions of temperature and relative humidity.

Adsorption.—Solids have the property of condensing and holding moisture on their surfaces. Coal possesses this property to a remarkable degree. If water be brought in contact with a pile of coal dust, a film of water forms on the outer layer of the pile, and it is exceedingly difficult to dampen the dust beneath this surface.

Coal dust.—Fine coal-dust particles provide nuclei on which moisture is readily deposited. In places where there is a total absence of dust, aqueous vapor may become supersaturated; that is, more than normal quantities may be present.

Convection.—Convection implies the transfer of heat by currents. In a mine convection is responsible for the movement of heat from warmer to the cooler portions of the air. It causes an intimate mixing of the air, and thereby facilitates evaporation and condensation.

Conduction.—Conduction implies the transfer of heat by molecular movement. By it heat flows from the zone of condensation or to the zone of evaporation.

WATER VAPOR AS A CATALYTIC AGENT.

Some gases do not explode in an absolutely dry atmosphere,^a but can be made to explode by a suitable means of ignition if small quantities of water vapor, which acts as a catalytic agent, be added. This fact, however, is relatively unimportant in the study of mine-air humidity, because all mine air carries at least a trace of water vapor.

WATER VAPOR AS AN INERT GAS.

Water vapor, if present in large quantities, retards ignition and the propagation of an explosion by diluting the explosive mixture. Furthermore, before an explosion can occur, the vapor must be raised to the ignition temperature of the gas and on account of the high specific heat of water, considerable heat is thus absorbed.

WEIGHT OF AIR.

The weight of a volume of air varies directly with the pressure and inversely with the temperature. At a pressure of 14.7 pounds per square inch, and at a temperature of 32° F., a cubic foot of pure dry air weighs 0.080728 pound. Table 3 shows the weight of 100,000 cubic feet of pure dry air at temperatures of 0° to 100° F. and with a uniform pressure of 14.7 pounds per square inch.

MOISTURE IN AIR.

Absolute humidity may be expressed as grains of water per cubic foot of air, but because of the large amounts of both air and water involved in studies of mine air it is more convenient to express absolute humidity as gallons of water per 100,000 cubic feet of air.

The amount of moisture in the form of aqueous vapor that may be present in a space occupied by air depends mainly on the temperature of the air. Table 3 gives the weight of saturated aqueous vapor in pounds and the quantity of water in gallons that will exist in a space occupied by 100,000 cubic feet of air when the relative humidity is 100 per cent and the temperature varies from 0° to 100° F.

Table 4 gives the changes in relative humidity that accompany increases in temperature from 0° to 100° F. if the quantity of water vapor remains constant.

The interrelation of the temperature and the relative humidity of mine air is of great importance. Tables 3 and 4 indicate (a) that it is not always sufficient for mine safety to have a relative humidity of 100 per cent at the intake of a mine, because if the entering air had a low temperature the aqueous vapor present would suffice for only a low relative humidity at the return; and (b) that to insure a proper

^a See Mellor, J. W., Chemical Statics and Dynamics, p. 471.

condition of the intake air both temperature and moisture must be added during the greater part of the year in order to prevent the extraction of large quantities of water from the mine by the ventilating current.

TABLE 3.—*Physical changes in air due to temperature.*

[Relative humidity, 100 per cent; pressure, 14.7 pounds per square inch.]

Temperature of the air.	Weight of 100,000 cubic feet of pure air.	Weight of water in 100,000 cubic feet of saturated aqueous vapor.	Quantity of water per 100,000 cubic feet of air.
° F.	Pounds.	Pounds.	Gallons.
0	8,635.4	6.9	0.823
10	8,459.4	11.1	1.329
20	8,275.5	17.6	2.114
30	8,106.3	27.6	3.312
40	7,943.9	40.7	4.878
50	7,787.9	58.2	6.979
60	7,637.9	82.1	9.843
70	7,493.5	114.0	13.686
80	7,354.6	156.2	18.776
90	7,220.6	211.3	25.439
100	7,091.4	282.4	34.058

TABLE 4.—*Changes in relative humidity due to temperature.*

[Quantity of water assumed to be constant.]

Temperature of air.	Quantity of water per 100,000 cubic feet of air.	Relative humidity.	Temperature of air.	Quantity of water per 100,000 cubic feet of air.	Relative humidity.
° F.	Gallons.	Per cent. Supersaturated.	° F.	Gallons.	Per cent.
0	1.329	100	60	1.329	14
10	1.329	63	70	1.329	10
20	1.329	40	80	1.329	8
30	1.329	27	90	1.329	7
40	1.329	19	100	1.329	6
50	1.329				

RÉSUMÉ OF MINE-HUMIDITY INVESTIGATIONS IN UNITED STATES.

CARL SCHOLZ.

Scholz, in October, 1908, drew attention to the fact that dust explosions in Oklahoma occurred only during the dry periods of the year.^a He concluded from a series of observations that "the hygro-metric condition of the atmosphere has the greatest effect upon the cause of explosions; and since this is a matter which can be controlled without much expense, it is believed that the application of a vaporizing system in mines which are dusty and generate fire damp will prove a remedy."

^a Scholz, Carl, Effect of humidity on mine explosions: Trans. Am. Inst. Min. Eng., vol. 39, 1908, pp. 328-336.

H. N. EAVENSON.

Eavenson, in November, 1908, prepared tables that show the average monthly weight of aqueous vapor and the average monthly temperatures in the outside atmosphere in the Appalachian coal fields.^a He also presented the results of humidity observations in five mines in McDowell and Logan Counties, W. Va., where the quantity of air delivered by the fans ranged from 102,000 to 200,000 cubic feet per minute. He concluded from these figures that "during the winter months water is removed from the mine by the ventilating current at rates of 21 to 69 tons per 24 hours, and that in the summer months it is deposited in the same mines at rates of 12 to 23 tons in 24 hours. Can anyone doubt that the removal of such an amount of moisture from the mine air of mines apt to be dusty may convert a mine ordinarily safe into one liable to cause a terrific explosion, if anything should happen to raise the temperature to the explosion point of the dust?"

FRANK HAAS.

Haas^b has given valuable information based on tests extending over a full year (June 1, 1908, to May 31, 1909) in certain mines near Fairmont, W. Va. The results of his investigation may be summarized as follows:

(a) Coal dust, in an atmosphere of 100 per cent relative humidity, absorbs a small amount of water, the exact amount depending on the nature of the dust and also on the length of time the dust is exposed.

(b) The suggestion is made that the evaporation of sufficient water will cool the temperature of an explosion below the ignition point of the coal dust.

(c) Temperature and humidity readings taken of the outside air and of the return air in the mines in question after being plotted on charts form the basis for the conclusion that an ordinary mine will show a large accumulated deficit of water per year. "Two months during the year the quantity of water taken into the mine by the air is in excess of that taken out. This period is approximately from the middle of June to the middle of August. Hence it appears that [in that district] artificial means of watering is necessary during the greater part of the year—from August 15 to June 15."

(d) Radiation from the side walls of an entry has considerable effect in raising the temperature of the air. In 4,000 feet of entry, where the average velocity was 453 feet per minute and the cross section 147 square feet, "over 30,000 British thermal units had been

^a Eavenson, H. N., Effect of humidity on mine explosions: Trans. Am. Inst. Min. Eng., vol. 40, 1909, pp. 835-846.

^b Haas, Frank, Exhaust steam as a preventive of dust explosions: Bull 20, Bureau of Mines, 1911, pp. 166-179.

radiated per minute, which would be equivalent to heat derived from burning over a ton of coal per day." In this particular test, the temperature of the air at the intake was about 24° F. and at the return 51° F.

(e) The quantity of water that can be carried mechanically in the form of a fog depends on the velocity of the air current. In order to prevent the fog line from advancing to the working face, three methods are suggested, as follows: First, reducing the volume and thereby the velocity of the air current; second, increasing the number or area of the airways; and, third, so changing the air courses that the distance to the working face is increased.

BUREAU OF MINES INVESTIGATORS.

The Bureau of Mines, at the Pittsburgh laboratories during September, 1909, carried on some interesting experiments to test the explosibility of coal dust under varying humidity conditions.^a These tests were conducted in a 100-foot explosion gallery. All shots were made with 2½ pounds of black powder tamped with clay. The amount of dust was 120 pounds, of which 20 pounds were placed on a horse in front of the shot and 100 pounds distributed on side shelves running along the full length of the gallery, 1 pound per linear foot. A definite quantity of water was mechanically mixed with pure, high-volatile, 100-mesh coal dust, and the air current entering in the gallery was heated and humidified by compressed-air water sprays.

The results of these experiments indicated that slight dampness of the dust was not sufficient to prevent flame propagation by an explosion, but that there could be no propagation when the total moisture content of the dust approached 30 per cent. This amount of moisture did not make the 100-mesh dust exceedingly wet, as the dust could be formed into balls in the hand without any of the water being squeezed out. If more moisture is added, the critical point is reached, and with about 40 per cent the mixture becomes a coal mud.

The conclusion is drawn that "these experiments, though they must be accepted as preliminary, give a definite figure for the percentage of moisture that makes coal dust relatively safe under ordinary conditions. As a pure 100-mesh coal dust was used in the experiments, a larger amount of moisture probably was needed to render it inert than if it had contained larger particles, or had been less pure, or had been mixed with shale dust. The tests probably represented extreme conditions."

^a Rice, G. S., The explosibility of coal dust, with chapters by J. C. W. Frazer, Axel Larsen, Frank Haas, and Carl Scholz. Bull. 20, Bureau of Mines, 1911, 204 pp.

MINE-HUMIDITY INVESTIGATIONS IN ILLINOIS.

STATEMENT OF PROBLEMS.

A minimum quantity (usually 100 cubic feet) of air per man per minute is required by State law for the ventilation of coal mines. This air must be delivered to the places where the miners are working. In an average mine in Illinois it may be assumed that 100,000 cubic feet of air per minute is put into circulation, a quantity of air that will weigh 4 tons and may be represented by the volume of an entry 10 feet wide by 6 feet high by 1,667 feet long. As the ventilating machinery is kept in continuous operation, the volume of air passing through the mine in 24 hours will weigh 5,760 tons and may be represented by the volume of still air contained in an entry 10 feet by 6 feet by 453 miles long.

The maximum amount of aqueous vapor that can exist in any given space varies directly with the temperature. For example: In winter when the outside temperature is only 20° F. there is little moisture in the air. When this air enters the mine and is heated to a temperature of 65° F. it is able to carry much more moisture, and in order to obtain the moisture it evaporates water from the coal dust and the mine surfaces and thus renders the dust more inflammable.

The general method adopted to obtain information on the changes in temperature and relative humidity that air undergoes in passing through coal mines, and also to learn the effect of seasonal variations on the humidity of mine air, was to install hygrographs and thermographs at central points for continuous records of the outside atmosphere and to install hygrometers near the intake and return-air shafts of a number of representative mines to obtain records of the mine air.

RECORDS OF OUTSIDE ATMOSPHERE.

The United States Weather Bureau cooperated with the three cooperators doing the work herein reported and installed self-registering recorders of temperature (thermographs) and of humidity (hygrographs) at La Salle and Springfield, Ill., and at St. Louis, Mo.

Similar instruments were already in operation at the University station at Urbana.

At Carbondale, Ill., a thermograph and a hygrograph were installed by the investigators in connection with the equipment being used at the local weather bureau.

The charts received from these stations give a continuous record of the temperature and relative humidity of the outside air for the period February, 1912, to April, 1913.

The situation of these stations is indicated in the tabulation following, and in figure 1.

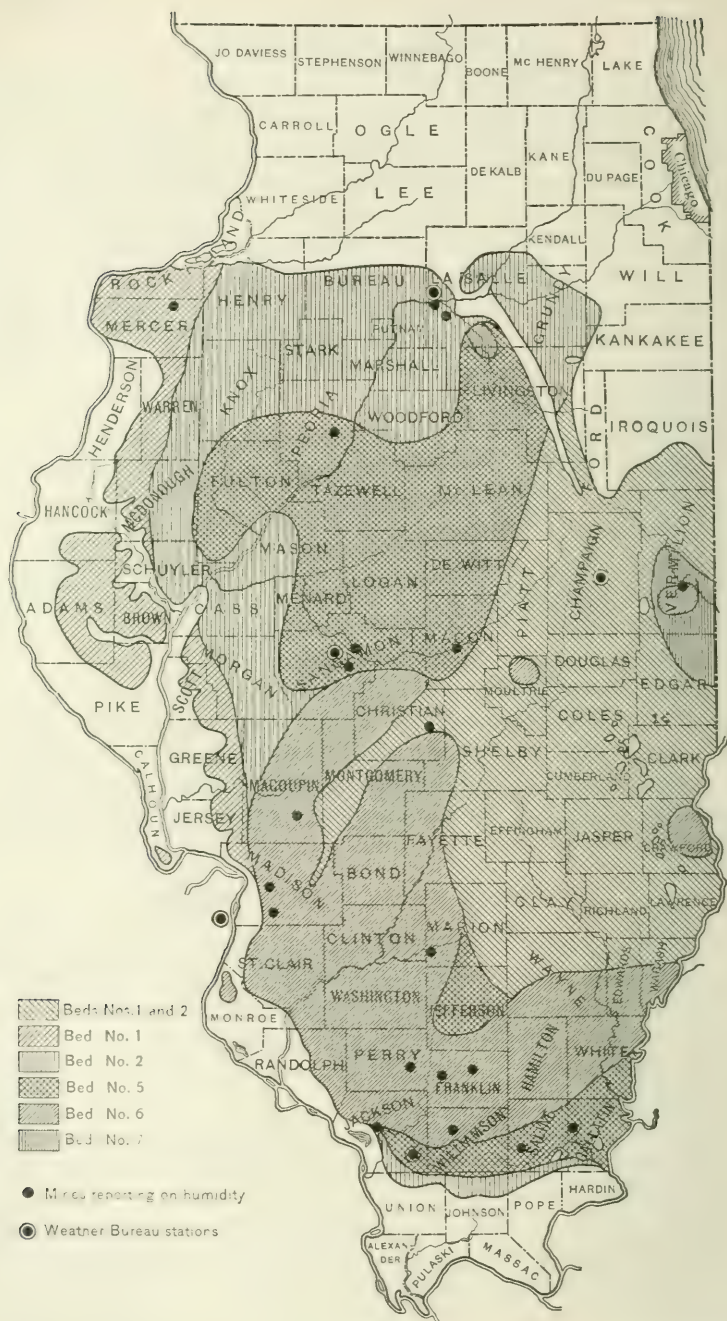


FIGURE 1. - Approximate coal areas (Bement) showing mines and United States Weather Bureau hygrograph stations that recorded humidity.

Stations reading weather conditions.

Name of station.	Town.	County.	Part of State.
U. S. Weather Bureau.....	La Salle.....	La Salle.....	Northern.
Do.....	Springfield.....	Sangamon (near).....	Central.
Do.....	St. Louis, Mo.....	St. Clair (near).....	Southwestern.
University of Illinois.....	Urbana.....	Champaign.....	Eastern.
Mining investigation and local observer.....	Carbondale.....	Jackson.....	Southern.

RECORDS OF MINE AIR.

To learn the moisture content of the mine air, 20 mines were selected to represent the average conditions in the State. In each of these mines two hygrometers were installed—one in the intake air course and one in the return air course. In order that the proper rate of evaporation from the surface of the wet bulb might be obtained, the hygrometers were placed at points where the velocity of the air was at least 600 feet per minute.

The intake hygrometer, which in each mine was installed within 300 feet of the downcast shaft, gave records of the average daily amount of moisture carried by the ventilating current as it entered the underground workings. These readings therefore supplemented the Weather Bureau observations by showing the changes in the temperature and relative humidity of the air due to variations in the shaft conditions, such as depth, amount of falling water, and presence of steam and water pipes. The return hygrometer was placed at a point within 500 feet of the upcast shaft, and showed the moisture content of the air leaving the mine. The readings of both hygrometers were made by local officials of each mine three to six times for each 24 hours, and the results were forwarded to Urbana for tabulation.

The names of the mines that furnished hygrometric data are given in Table 5, following:

TABLE 5.—*Mines furnishing hygrometric data, hours of reading, and names of readers.*

Name of mine.	Company.	Town.	County.	Hours of reading.	Name of reader.
Oglesby.....	Oglesby Coal Co...	Oglesby.....	La Salle....	7 a. m., 12 m., 4 p. m.	D. W. Kelly.
La Salle shaft...	La Salle County Carbon Coal Co.	La Salle....	do.....	7 a. m., 12 m., 3.30 p. m., 9.30 p. m.	J. G. Millhouse.
No. 9.....	Big Muddy Coal & Iron Co.	Murphysboro.	Jackson.....	do.....	J. M. Mitchell.
No. 2.....	Coal Valley Mining Co.	Sherrard....	Mercer.....	7 a. m., 12 m., 4 p. m.	R. E. Lee.
No. 1.....	Assumption Coal Mining Co.	Assumption.	Christian....	8 a. m., 12 m., 4 p. m.	T. J. Connolly.
Empire No. 2....	Clark Coal & Coke Co.	Peoria.....	Peoria.....	8 a. m., 11 a. m., 2 p. m.	R. U. Tyson.
Peerless No. 1...	Jones & Adams Coal Co.	Springfield..	Sangamon....	8 a. m., 12 m., 4 p. m.	P. W. MacMurdo.
Woodside.....	Woodside Coal Co.	do.....	do.....	do.....	Robert Wilson.
Longwall M. & C.	Manufacturers & Consumers Coal Co.	Decatur.....	Macon.....	7.30 a. m., 11.30 a. m., 3.30 p. m.	Louis White.
No. 3.....	Saline County Coal Co.	Harrisburg..	Saline.....	7 a. m., 12 m., 4 p. m.	Walter Scott.

TABLE 5.—*Mines furnishing hygrometric data, hours of reading, and names of readers—Continued.*

Name of mine.	Company.	Town.	County.	Hours of reading.	Name of reader.
Equality No. 1.	Gallatin Coal & Coke Co.	Equality....	Gallatin....	7 a. m., 12 m., 4 p. m.	J. B. Smith.
Hart-Williams...	Hart-Williams Coal Co.	Benton.....	Franklin....	8 a. m., 12.30 p. m., 4.30 p. m., 9 p. m., 12 a. m., 4 a. m.	C. O. Wellington, Robt. Waugh.
Paradise.....	Paradise Coal & Coke Co.	Duquoin....	Perry.....	7 a. m., 12 m., 4 p. m.	J. H. Lester, Hugh McGonaghie.
East Mine.....	United Coal Mining Co.	Christopher.	Franklin....	do.....	Walter Stephens.
Big Muddy.....	Chicago & Big Muddy Coal Co.	Marion.....	Williamson.	8 a. m., 12 m., 3 p. m.	A. B. McClaren; J. L. Moses.
No. 3.....	Superior Coal Co.	Gillespie....	Macoupin....	7 a. m., 12 m., 4 p. m.	Philip White, D. E. Reese.
Madison No. 2...	Madison Coal Corporation.	Glen Carbon	Madison.....	do.....	William Turton.
Lumaghi No. 2..	Lumaghi Coal Co.	Collinsville..	do.....	8 a. m., 12 m., 4 p. m., 6 p. m.	W. T. Scully.
No. 5.....	Centralia Coal Co.	Centralia....	Marion.....	8 a. m., 1 p. m., 3 p. m.	J. H. Hoyer.
Little Vermilion.	Bunsen Coal Co.	Westville....	Vermillion...	7 a. m., 12 m., 4 p. m.	W. B. Wiley.

CALCULATION AND TABULATION OF RESULTS.

The monthly reports from the Weather Bureau stations contained for each two-hour interval the average temperature and relative humidity of the outside atmosphere. The daily-report cards from the 20 mines contained records of the quantity of air in circulation underground and at least three readings of the wet-bulb and of the dry-bulb thermometers of the intake and return hygrometers. From these records the average daily readings were obtained and the results recorded in the weekly humidity reports. By further combination the average weekly readings were computed and calculations were made of the quantity of water per 100,000 cubic feet of air and also of the quantity of water deposited or extracted per 24 hours. A specimen daily-report card and a specimen weekly humidity report are shown below.

Specimen daily report card of mine-humidity reading.

DAILY REPORT.

DATE: 4-1-1912.

Mine, Paradise. Address, Duquoin, Ill.
Total air in mine, 66,500 cu. ft. per min.

Return air:

	Time.	Dry bulb.	Wet bulb.
Velocity	7 a. m.	60½	59½
520			
Area	12 m.	60½	59½
96			
	4 p. m.	60½	60

Intake air:

	Time.	Dry bulb.	Wet bulb.
Velocity	7 a. m.	31	30
1,478			
Area	12 m.	34	30
45			
	4 p. m.	36	33

(Signed)

JAS. H. LISTER,
Mine manager.

*Specimen weekly humidity report.***WEEKLY HUMIDITY REPORT.**

No. 17.

Mine name, Sherrard No. 2.

Operator, Coal Valley Mining Co. Address, Sherrard.

Total air current, 52,000 cu. ft. per minute.

Week ending May 12, 1912.

Average readings.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.	Sunday.
OUTSIDE AIR.							
Dry bulb.....(t).....	68 $\frac{1}{2}$	67 $\frac{1}{2}$	62	61	66 $\frac{1}{2}$	58	46 $\frac{1}{2}$
Wet bulb.....(t').....							
Depression.....(t-t').....							
Rel. humidity.....(%).....	64	66	55	56	59	89	83
INTAKE AIR.							
Dry bulb.....(t).....	66 $\frac{1}{2}$	63 $\frac{1}{2}$	58 $\frac{3}{4}$	58 $\frac{1}{2}$	59 $\frac{1}{2}$	63 $\frac{1}{2}$	63 $\frac{1}{2}$
Wet bulb.....(t').....	64 $\frac{1}{2}$	61 $\frac{1}{2}$	57 $\frac{1}{2}$	57	57 $\frac{1}{2}$	61 $\frac{1}{2}$	61 $\frac{1}{2}$
Depression.....(t-t').....	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Rel. humidity.....(%).....	90	90	91	91	89	92	92
RETURN AIR.							
Dry bulb.....(t).....	67 $\frac{3}{4}$	68	67 $\frac{3}{4}$	67 $\frac{1}{2}$	67 $\frac{3}{4}$	67 $\frac{3}{4}$	67 $\frac{1}{2}$
Wet bulb.....(t').....	67 $\frac{3}{4}$	66 $\frac{3}{4}$	66 $\frac{1}{2}$	66 $\frac{1}{2}$	66 $\frac{1}{2}$	66 $\frac{1}{2}$	66 $\frac{1}{2}$
Depression.....(t-t').....	1 $\frac{1}{4}$	1 $\frac{1}{4}$	1 $\frac{1}{4}$	1	1	1 $\frac{1}{4}$	1
Rel. humidity.....(%).....	97 $\frac{1}{2}$	94	94	95	95	94	95
Computations from average readings.	Dry bulb (t) ° F.	Depression of wet bulb (t-t').	Relative humidity %.	Gals. water per 100,000 cu. ft. air.	Gals. water per total air 24 hours.	Gals. artificially introduced per 24 hrs.	Gals. of water, extracted, (-), deposited (+), per 24 hrs.
Outside air.....	61 $\frac{1}{2}$		67	6.85	5,147		
Intake air shaft.....	61 $\frac{1}{2}$	1 $\frac{1}{2}$	91	9.65	7,414		
Return air shaft.....	67 $\frac{3}{4}$	1	95	12.08	9,032		

After the investigation had continued for one year, tabulations (Table 6), from the weekly averages were made showing the temperature, relative humidity, and actual moisture content (gallons of water per 100,000 cubic feet of air) of the outside atmosphere and of the intake and the return air in each of the 20 mines. Typical results of these tabulations are plotted in figures 2 and 3.

METHOD OF USING PSYCHROMETRIC TABLES.^a

In order to show the method of using psychrometric tables, a determination is given in full below:

1. Information given and to be obtained:

Reading.	Mine intake.	Mine return.
Area.....		10 by 16 feet.
Velocity.....		625 feet per minute.
Barometer.....	b 30	b 30
Dry bulb (t).....	10°	60°
Wet bulb (t').....	8°	59 $\frac{1}{2}$ °

^a Marvin, C. F., Psychrometric tables for obtaining the vapor pressure, relative humidity, temperature of the dew point, and grains of water per cubic foot of air: U. S. Weather Bureau, Bull. 235, 1900.

^b The normal barometer reading for any mine in Illinois may be assumed at 30 inches. Any error resulting from this assumption is exceedingly small.

2. Use of the tables:

(a) Quantity of air passing through mine—

$$\text{Area} \times \text{velocity} = 160 \times 625 = 100,000 \text{ cubic feet per minute.}$$

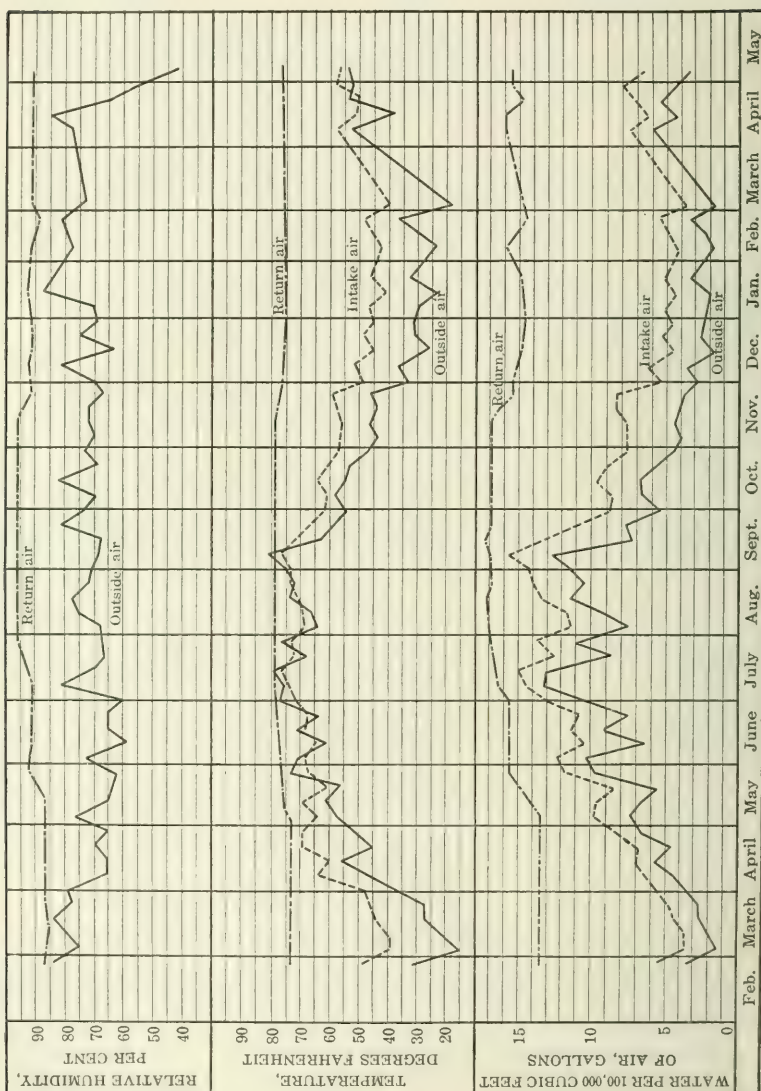


FIGURE 2.—Curves plotted from hygrometric records of a typical long-wall mine in La Salle County, Ill.

(b) Depression of wet-bulb thermometer—

$$\text{Intake air: } (t - t') = (10 - 8) = 2^\circ.$$

$$\text{Return air: } (t - t') = (60 - 59\frac{1}{2}) = \frac{1}{2}^\circ.$$

(c) Relative humidity (U. S. Weather Bureau Bull. 235, Table 7)—

Relative humidity of intake air, with air temperature = 10° and depression of wet bulb = 2° = 56 per cent.

Relative humidity of return air, with air temperature= 60° and depression of wet bulb= $\frac{1}{2}^{\circ}$ =97 per cent.

(d) Quantity of water per cubic foot of air (Bull. 235, Table XII):

Quantity of water in intake air, with air temperature= 10° and with the relative humidity=56 per cent=0.435 grains per cubic foot of air.

Quantity of water in return air, with air temperature= 60° and with the relative humidity=97 per cent=5.573 grains per cubic foot of air.

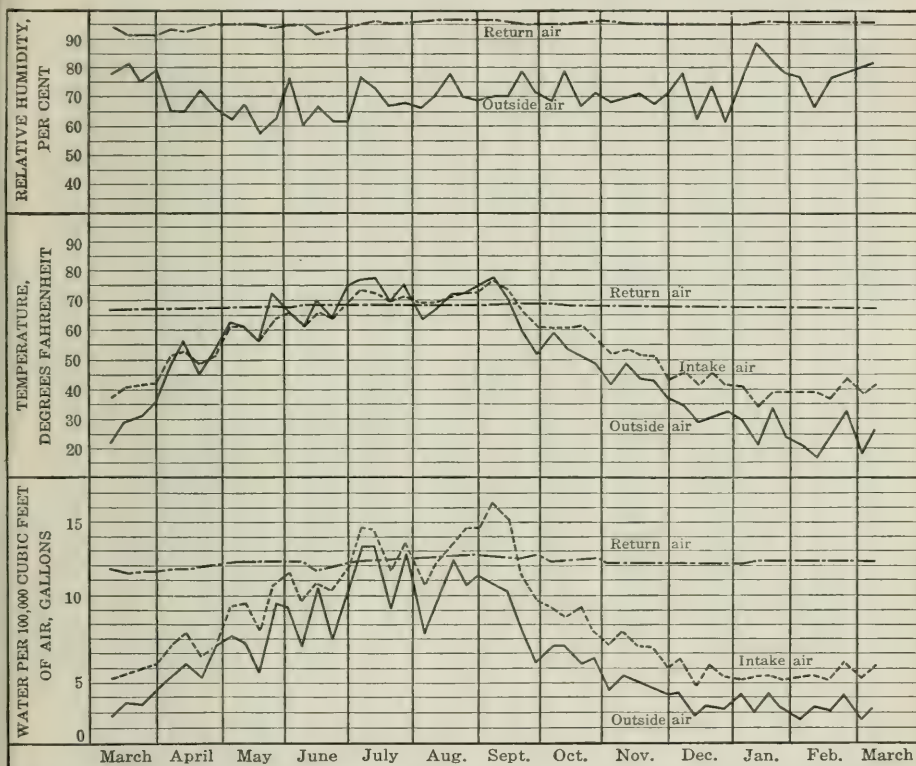


FIGURE 3.—Curves plotted from hygrometric records of a typical room-and-pillar mine in Mercer County, Ill.

(e) Gallons of water per 100,000 cubic feet of air—

If 1 pound avoirdupois=7,000 grains and 1 gallon of water at ordinary temperatures weighs 8.35 pounds, then:

Gallons per 100,000 cubic feet of intake air—

$$\frac{0.435 \times 100,000}{7,000 \times 8.35} = 0.744 \text{ gallon.}$$

Gallons per 100,000 cubic feet of return air—

$$\frac{5.573 \times 100,000}{7,000 \times 8.35} = 9.535 \text{ gallons.}$$

(f) Extraction or deposition of moisture—

The amount of air passing through the mine is 100,000 cubic feet per minute; therefore every minute $9.535 - 0.744 = 8.791$ gallons of water are extracted from the mine. Reducing this amount to 24 hours, we find that under the assumed conditions an enormous quantity is taken daily from the mine, namely, $8.777 \text{ gallons} \times 60 \text{ minutes} \times 24 \text{ hours} = 12,659 \text{ gallons} = 52.85 \text{ tons of water a day.}$

HYGROMETRIC RECORDS.

Table 6, giving the weekly averages of the hygrometric records made, is presented below:

TABLE 6.—Weekly averages of hygrometric records made in Illinois cooperative investigations.

OGLESBY MINE, OGLESBY COAL CO., LA SALLE COUNTY.

Week ending—	Temperature.			Relative humidity. ^a			Water in 100,000 cubic feet.		
	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.
1912.	° F.	° F.	° F.	Per cent.	Per cent.	Per cent.	Gallons.	Gallons.	Gallons.
Mar. 3	15.00	28.44	71.17	74.00	97.00	89.67	1.25	2.34	12.74
10	21.00	29.92	71.17	83.00	95.50	95.93	1.75	3.15	13.55
17	27.50	34.56	71.00	83.00	83.67	97.00	2.46	3.33	13.71
24	28.67	36.77	71.83	77.00	89.00	96.50	2.41	3.85	14.01
31	36.33	39.00	71.60	77.00	89.60	94.00	3.28	4.21	13.54
June 30	76.00	70.33	75.00	61.00	85.00	91.00	10.11	11.76	14.61
July 7	75.92	73.67	75.73	79.00	90.00	96.00	13.06	13.85	15.77
14	77.42	73.82	76.13	75.00	86.00	99.67	12.20	13.30	16.58
21	69.42	68.13	76.67	64.00	82.50	100.00	8.60	10.63	16.92
28	76.60	73.60	76.60	69.00	86.60	100.00	11.65	13.30	16.89
Aug. 4	65.58	66.67	76.50	67.00	80.00	100.00	7.94	9.83	16.83
11	67.00	67.50	76.33	80.00	84.17	100.00	9.93	10.62	16.74
18	70.67	70.13	76.22	79.00	90.33	100.00	11.05	12.42	16.69
25	72.25	71.33	76.83	72.00	89.00	99.83	10.59	12.71	16.98
Sept. 1	74.00	72.67	77.00	72.00	86.00	100.00	11.20	12.82	17.10
8	80.15	76.47	77.00	70.00	85.00	100.00	13.20	14.30	17.10
15	62.33	71.33	77.00	67.50	82.00	100.00	7.19	11.71	17.10
22	59.33	63.56	76.50	82.00	84.00	100.00	7.89	9.31	16.83
29	54.13	58.33	76.00	73.00	79.00	100.00	5.88	7.35	16.57
Oct. 6	58.33	58.23	75.00	69.00	80.00	100.00	6.42	7.42	16.05
13	55.00	60.67	75.00	82.00	85.00	95.00	6.81	8.56	15.25
20	53.33	58.08	75.00	68.00	80.50	95.00	5.33	7.43	15.25
27	47.00	51.67	75.00	73.00	80.00	86.00	4.58	5.92	13.81
Nov. 3	44.50	50.83	74.83	70.00	79.00	88.00	4.02	5.68	14.05
10	46.33	51.50	73.83	72.00	80.00	90.67	4.42	6.09	14.48
17	43.33	50.39	74.33	72.50	81.67	84.00	3.99	5.78	13.21
24	45.33	48.94	73.67	66.00	80.00	96.67	3.90	5.38	14.91
Dec. 1	34.00	40.67	73.07	70.00	80.80	99.80	2.73	4.04	15.08
8	35.30	43.13	73.00	80.00	85.00	99.80	3.28	4.65	15.04
15	26.00	35.22	72.67	62.00	80.00	99.00	1.72	3.27	14.76
22	31.67	39.44	72.44	75.00	85.00	99.83	2.67	4.07	14.78
29	31.60	37.20	71.80	69.00	86.00	100.00	2.45	3.78	14.50

LA SALLE MINE, LA SALLE COUNTY CARBON COAL CO., LA SALLE COUNTY.

1912.									
Feb. 25	32.83	49.33	74.00	83.00	86.33	86.00	3.10	5.89	13.38
Mar. 3	15.00	39.67	74.13	74.00	82.33	85.50	1.25	3.95	13.35
10	21.00	39.25	74.17	79.00	82.00	85.00	1.75	3.89	13.29
17	27.50	43.00	74.00	83.00	79.00	85.33	2.47	4.30	13.33
24	28.67	45.50	74.00	77.00	82.00	86.00	2.41	4.86	13.38
May 5	59.67	47.50	74.00	77.00	86.00	86.00	7.36	5.41	13.38
12	61.75	64.25	76.00	65.00	84.25	87.00	6.80	9.56	14.38
19	56.00	58.90	76.00	64.00	86.00	90.00	5.50	8.15	14.91
26	74.50	68.67	76.25	61.00	89.00	93.00	9.64	11.66	15.53
June 2	70.25	69.88	76.50	77.00	90.00	92.75	10.55	12.27	15.61
9	61.66	64.33	77.00	59.00	90.00	91.00	6.14	10.24	15.56
16	71.00	68.00	77.00	67.00	90.00	91.00	9.47	11.54	15.56
23	64.00	66.20	77.00	67.00	89.00	91.00	7.54	10.76	15.56
30	77.50	72.50	77.00	59.50	88.00	91.00	10.34	13.05	15.56
July 7	76.33	74.67	78.00	80.00	92.00	91.33	13.40	14.61	16.11
14	78.50	76.33	78.00	72.00	90.50	92.50	12.91	15.15	16.32
21	68.00	71.75	78.00	66.50	85.00	94.50	8.53	12.26	16.67
28	76.00	73.25	78.00	67.00	91.33	96.00	11.11	13.87	16.94
Aug. 4	64.50	68.50	78.00	68.00	85.00	96.00	7.78	11.08	16.94
11	66.50	68.87	78.25	75.00	88.00	96.00	9.16	11.61	17.01
18	73.20	71.75	78.40	77.00	93.00	96.00	11.68	13.47	17.15
25	72.25	73.00	78.00	72.00	93.00	96.00	10.60	14.01	16.94

^a The 100 per cent relative humidity of the return air, as reported from July 14 to Oct. 6, is too high, the error being due to the failure of the wicking to conduct water from the cup to the wet-bulb thermometer. This failure was caused by the clogging of the wick by impurities in the water and by dust settling from the air currents.

TABLE 6.—Weekly averages of hygrometric records made in Illinois cooperative investigations—Continued.

LA SALLE MINE, LA SALLE COUNTY CARBON COAL CO., LA SALLE COUNTY—Contd.

Week ending—	Temperature.			Relative humidity.			Water in 100,000 cubic feet.		
	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.
1912.	° F.	° F.	° F.	Per cent.	Per cent.	Per cent.	Gallons.	Gallons.	Gallons.
Sept. 1	74.33	73.67	78.00	71.00	93.00	96.00	11.16	14.31	16.94
8	80.00	77.00	78.25	68.00	93.00	96.00	12.77	15.90	17.01
15	62.33	72.75	78.50	67.50	87.33	96.00	7.22	13.08	17.20
22	59.33	67.00	78.00	82.00	87.00	96.00	7.89	10.80	16.94
29	54.13	62.50	78.00	73.00	84.00	96.00	5.88	8.99	16.94
Oct. 6	58.33	61.00	78.00	69.00	85.50	96.00	6.42	8.70	16.94
13	55.00	64.67	78.00	82.00	84.50	96.00	6.81	9.72	16.94
20	53.67	61.00	78.00	68.00	88.00	96.00	5.40	8.96	16.94
27	47.00	57.25	78.00	73.00	86.67	96.00	4.58	7.77	16.94
Nov. 3	44.50	56.87	78.00	70.00	86.00	96.00	4.02	7.63	16.94
10	46.33	56.00	78.00	72.00	89.00	96.00	4.42	7.65	16.94
17	43.33	57.67	77.67	72.50	90.87	94.00	3.99	8.25	16.41
24	45.33	58.13	77.00	66.00	88.00	91.00	3.90	8.13	15.56
Dec. 1	34.00	49.40	76.80	70.00	81.60	91.00	2.73	5.58	15.46
8	36.00	52.50	76.17	81.50	83.83	91.83	3.42	6.39	15.30
15	26.00	45.00	75.83	62.00	79.33	90.33	1.72	4.64	14.89
22	31.67	49.00	75.67	75.00	83.00	90.33	2.67	5.59	14.81
29	31.60	45.25	75.00	69.00	78.00	91.00	2.45	4.77	14.61
1913.									
Jan. 5	29.90	47.00	75.00	70.40	82.00	91.00	2.40	5.15	14.61
12	22.17	42.00	75.00	87.50	81.00	92.00	2.03	4.25	14.77
19	33.65	46.67	75.17	84.17	82.00	91.00	3.22	5.09	14.86
26	28.47	45.33	75.50	80.00	80.00	91.00	2.48	4.76	15.34
Feb. 2	23.38	43.50	75.75	77.00	79.75	91.00	1.90	4.42	15.71
9	37.66	49.00	75.33	80.17	83.67	88.00	3.59	5.64	14.28
Mar. 2	18.47	40.00	75.00	74.00	76.00	91.00	1.46	3.71	14.61
Apr. 6	53.83	58.00	76.00	78.67	84.67	91.00	6.27	7.79	16.07
13	39.25	52.64	76.00	85.75	79.50	91.00	4.06	6.09	16.07
20	54.47	50.50	76.75	65.50	83.00	91.75	5.34	5.90	14.74
27	53.33	58.75	77.00	57.00	84.75	91.00	4.51	8.00	15.56
May 4	54.25	57.67	77.00	40.00	82.00	91.00	3.24	7.46	15.56

MINE NO. 9, BIG MUDDY COAL & IRON CO., MURPHYSBORO, JACKSON COUNTY.

1912.									
Feb. 11	-----	42.88	48.90	-----	70.00	100.00	-----	3.79	6.72
18	-----	45.50	52.50	-----	74.50	100.00	-----	4.43	7.62
25	-----	46.25	56.00	-----	73.00	100.00	-----	4.46	8.59
Mar. 3	-----	44.00	55.90	-----	74.00	100.00	-----	4.17	8.56
10	-----	43.50	56.67	-----	77.50	100.00	-----	4.29	8.79
17	-----	45.50	57.00	-----	82.00	100.00	-----	4.88	8.89
24	-----	51.00	57.50	-----	85.00	100.00	-----	6.14	9.08
31	-----	51.50	57.67	-----	87.00	100.00	-----	6.40	9.15
Apr. 7	63.00	55.50	58.00	67.00	85.00	100.00	7.29	7.18	9.20
14	62.00	56.50	58.00	68.00	86.00	100.00	7.16	7.52	9.20
21	-----	56.25	58.25	-----	82.00	99.75	-----	7.13	9.26
28	60.50	56.20	58.25	61.00	84.00	99.85	6.11	7.27	9.14
May 5	69.00	60.13	59.00	72.00	93.00	100.00	9.54	9.20	9.52
12	70.20	62.80	59.00	70.00	93.50	100.00	9.64	10.11	9.52
19	61.75	57.88	58.50	69.00	82.25	100.00	7.26	8.65	9.36
26	76.80	67.00	59.50	65.00	93.00	100.00	11.04	11.21	9.68
June 2	71.00	65.67	60.00	72.00	94.00	100.00	10.18	11.17	9.84
9	71.00	65.00	60.00	63.00	87.60	100.00	8.90	10.18	9.84
16	71.50	66.50	60.00	74.00	90.00	100.00	10.63	10.99	9.84
23	62.00	64.50	60.00	85.00	95.67	100.00	8.95	10.94	9.81
30	68.00	66.90	60.00	85.00	96.33	100.00	10.91	11.92	9.84
July 7	73.60	71.80	60.33	89.00	99.80	100.00	13.66	14.47	9.95
14	77.00	73.50	61.25	83.00	98.67	100.00	14.19	15.10	10.27
21	75.00	72.75	61.50	83.00	98.40	100.00	13.32	14.71	10.35
28	78.00	73.25	61.50	77.00	99.00	100.00	13.15	15.04	10.35
Aug. 4	71.00	69.33	61.08	75.00	94.00	100.00	9.59	12.59	10.21
11	67.60	67.90	61.00	76.00	90.80	100.00	9.62	11.61	10.18
18	75.20	72.83	61.00	85.00	99.00	100.00	13.73	14.83	10.18
25	71.17	73.00	61.67	84.00	95.00	100.00	13.13	14.31	10.41
Sept. 1	76.33	73.50	62.00	79.00	96.50	100.00	13.22	14.77	10.53
8	78.75	75.00	62.00	75.00	91.00	100.00	13.54	14.61	10.53
15	70.00	71.50	62.00	71.00	90.00	100.00	9.72	12.93	10.53
22	64.20	67.67	61.50	86.00	93.00	99.00	6.74	11.80	10.25
29	54.00	62.50	61.00	81.00	80.67	100.00	6.50	8.63	10.18

TABLE 6.—Weekly averages of hygrometric records made in Illinois cooperative investigations—Continued.

MINE NO. 9, BIG MUDDY COAL & IRON CO., MURPHYSBORO, JACKSON COUNTY—Con.

Week ending—	Temperature.			Relative humidity.			Water in 100,000 cubic feet.		
	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.
	° F.	° F.	° F.	Per cent.	Per cent.	Per cent.	Gallons.	Gallons.	Gallons.
1912.									
Oct. 6	55.00	61.00	60.00	81.00	82.50	100.00	6.73	8.40	9.84
13	65.00	65.50	60.00	72.00	90.00	100.00	8.37	10.64	9.84
20	52.80	60.00	60.00	85.00	87.00	100.00	6.55	8.56	9.84
27	49.40	56.00	59.60	76.50	84.00	100.00	5.23	7.37	9.71
Nov. 3	50.67	54.00	59.10	76.50	81.00	100.00	5.60	6.50	9.55
10	48.67	55.00	57.00	65.00	77.00	100.00	4.33	6.40	8.89
17	39.33	54.33	59.00	80.33	73.00	100.00	3.83	5.93	9.52
24	43.75	53.60	58.33	61.00	71.50	100.00	3.66	5.66	9.31
Dec. 1	34.50	48.00	58.00	64.50	74.00	100.00	2.67	4.82	9.20
8	41.00	50.50	58.00	77.60	77.50	100.00	3.93	5.51	9.20
15	25.50	43.30	57.75	65.50	66.00	99.50	1.77	3.63	9.07
22	31.00	46.33	57.67	78.00	72.00	100.00	2.69	4.41	9.09
29	30.00	45.17	57.00	75.00	76.67	100.00	2.48	4.51	8.89
1913.									
Jan. 5	33.50	46.67	57.17	71.00	75.00	100.00	2.72	4.65	8.94
12	29.20	45.33	57.17	92.00	81.00	100.00	2.94	4.79	8.94
19	41.00	48.60	56.00	86.67	86.00	100.00	4.38	5.72	8.59
26	35.25	48.25	57.67	88.00	85.00	100.00	3.60	5.58	9.09
Feb. 2	30.25	44.25	57.25	70.00	71.00	100.00	2.35	4.04	8.97
9	16.50	42.83	51.50	80.00	81.00	100.00	1.45	4.28	7.36
16	27.00	45.25	55.00	64.00	78.00	100.00	1.86	4.59	8.31
23	52.00	51.67	57.00	78.00	81.33	100.00	5.84	6.98	8.89

SHERRARD NO. 2 MINE, COAL VALLEY MINING CO., MERCER COUNTY.

1912.									
Mar. 10	21.92	36.50	67.17	77.33	99.00	94.00	1.78	4.24	11.74
17	29.42	40.33	67.42	81.00	97.00	91.00	2.63	4.79	11.46
24	30.14	41.33	67.50	75.00	96.00	91.00	2.48	4.92	11.51
31	37.58	43.86	67.50	79.00	92.00	91.00	3.51	5.16	11.51
Apr. 7	48.50	51.08	67.42	65.00	96.00	94.00	4.30	6.96	11.83
14	57.50	53.25	67.67	65.00	93.00	93.00	5.97	7.46	11.80
21	45.83	48.00	67.75	72.00	91.00	94.00	4.36	5.92	11.96
28	52.58	51.57	67.58	66.00	90.00	95.00	6.60	6.64	12.02
May 5	63.75	60.25	67.63	63.00	93.00	95.00	7.02	9.22	12.04
12	61.33	61.75	67.89	67.00	91.00	95.00	6.85	9.50	12.14
19	55.88	55.67	67.50	57.00	89.00	95.33	4.89	7.56	12.13
26	73.71	64.83	68.00	63.00	92.00	94.00	9.71	10.63	12.05
June 2	66.17	66.58	67.92	76.00	93.71	95.00	9.13	11.42	12.15
9	62.70	61.75	68.00	60.00	92.00	95.00	6.42	9.60	12.18
16	70.00	67.25	68.00	67.00	86.00	92.00	10.54	10.77	11.80
23	64.00	64.75	68.00	63.00	87.57	93.00	7.08	10.10	11.93
30	75.83	69.33	68.00	63.00	85.00	94.00	10.43	11.76	12.05
July 7	77.17	74.50	68.25	77.00	92.00	95.71	13.16	14.54	12.37
14	78.33	73.92	68.25	74.00	93.00	96.00	13.19	14.28	12.41
21	69.67	69.92	68.50	67.00	86.43	95.71	9.17	11.80	12.48
28	75.58	72.50	68.50	68.00	90.14	96.00	12.76	13.37	12.51
Aug. 4	64.10	68.42	68.50	66.00	83.57	96.29	7.42	10.86	12.55
11	67.00	69.83	68.50	80.00	90.00	97.00	9.93	12.32	12.64
18	73.83	72.00	68.50	78.00	93.29	97.00	12.13	13.62	12.64
25	73.58	73.50	68.50	70.00	95.57	97.00	10.71	14.63	12.64
Sept. 1	75.83	73.83	68.50	69.00	95.29	97.00	11.13	14.71	12.64
8	77.92	76.50	68.50	70.00	96.71	97.00	12.30	16.28	12.64
15	71.67	74.92	68.83	70.00	95.00	96.33	10.17	15.21	12.63
22	59.92	66.58	69.00	79.00	92.50	95.00	7.78	11.33	12.59
29	53.17	62.17	69.00	72.00	91.00	95.00	5.58	9.64	12.59
Oct. 6	60.20	60.75	69.00	68.00	91.00	95.00	6.69	9.19	12.59
13	54.33	60.58	68.25	79.00	87.00	95.00	6.41	8.73	12.28
20	52.83	61.92	68.25	67.00	88.00	96.00	5.19	9.23	12.41
27	48.58	55.17	68.00	72.00	89.00	97.00	5.64	7.43	12.44
Nov. 3	43.83	53.00	68.00	69.00	89.00	97.00	3.75	6.90	12.44
10	48.00	54.00	68.00	70.00	93.43	95.00	4.55	7.50	12.18
17	44.25	52.14	68.00	72.00	88.43	95.00	4.10	6.65	12.18
24	43.60	51.71	68.00	67.00	88.71	95.00	3.87	6.57	12.18
Dec. 1	36.50	41.30	68.00	71.00	87.00	95.00	3.04	5.00	12.18
8	34.33	45.71	68.00	79.00	97.00	95.00	3.12	5.82	12.18
15	28.00	41.67	68.00	63.57	77.00	95.00	1.94	3.99	12.18
22	30.50	45.14	68.00	74.00	86.00	95.00	2.51	5.29	12.18
29	33.33	42.17	68.00	62.00	85.00	95.00	2.39	4.49	12.18

TABLE 6.—Weekly averages of hygrometric records made in Illinois cooperative investigations—Continued.

SHERRARD NO. 2 MINE, COAL VALLEY MINING CO., MERCER COUNTY—Continued.

Week ending—	Temperature.			Relative humidity.			Water in 100,000 cubic feet.		
	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.
	°F.	°F.	°F.	Per cent.	Per cent.	Per cent.	Gallons.	Gallons.	Gallons.
1913.									
Jan. 5	29.92	41.83	68.00	77.00	82.00	95.00	3.30	4.27	12.18
12	21.60	35.58	68.00	88.00	90.60	96.00	2.00	4.48	12.31
19	34.29	39.86	68.00	83.86	95.00	96.00	3.31	4.61	12.31
26	24.67	39.57	68.00	79.43	91.00	95.00	2.08	4.37	12.18
Feb. 2	21.88	39.33	68.00	76.14	95.00	96.00	1.69	4.52	12.31
9	16.58	39.50	68.00	67.29	98.00	96.00	2.22	4.69	12.31
16	25.58	37.00	68.00	76.00	98.00	96.00	2.06	4.28	12.31
23	33.29	44.50	68.00	79.50	94.00	96.00	3.02	5.36	12.31
Mar. 2	18.14	38.33	68.00	80.43	94.00	96.00	1.56	4.31	12.31
9	26.67	42.00	68.00	82.33	96.00	96.00	2.35	5.04	12.31

ASSUMPTION NO. 1 MINE, ASSUMPTION COAL & MINING CO., CHRISTIAN COUNTY.

Week ending—	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.
	°F.	°F.	°F.	Per cent.	Per cent.	Per cent.	Gallons.	Gallons.	Gallons.
1912.									
Feb. 18	36.25	41.50	62.50	81.00	86.00	84.00	3.44	4.43	8.44
25	31.25	41.67	63.25	76.00	88.00	88.00	2.67	4.56	9.65
Mar. 3	22.00	40.83	61.33	72.50	88.00	89.00	1.68	4.42	9.16
10	24.33	43.50	59.50	77.00	88.50	92.00	1.98	4.90	8.94
17	31.50	44.67	66.67	83.00	91.00	95.00	2.94	5.25	11.29
24	34.00	47.75	68.00	80.00	93.00	95.00	3.14	6.30	12.18
31	39.60	48.00	68.67	80.00	93.50	95.00	3.85	6.09	12.46
Apr. 21	48.00	55.00	69.83	70.00	93.00	93.67	4.56	7.72	12.75
28	57.50	56.50	70.00	60.00	94.00	95.00	5.43	8.23	13.00
May 5	63.00	59.75	70.00	75.00	95.00	95.00	8.16	9.27	13.00
12	67.50	64.67	69.00	65.00	97.00	97.67	8.20	11.16	12.94
19	54.50	58.50	68.67	67.00	94.00	94.00	5.47	8.79	12.32
26	74.67	66.83	70.17	59.00	95.67	95.00	9.37	11.81	13.07
June 2	68.00	67.83	71.17	75.00	96.40	95.00	9.62	12.03	13.50
9	65.50	64.00	71.83	55.50	95.67	97.00	6.56	10.76	14.08
16	72.75	66.00	72.50	62.50	97.67	96.00	9.35	11.61	14.34
23	64.00	65.50	72.67	70.00	97.00	97.00	7.87	11.47	14.46
30	75.33	68.67	73.00	66.00	96.33	97.70	10.71	12.63	14.72
July 7	77.00	73.75	74.00	78.00	97.00	96.50	13.34	14.97	15.01
14	78.67	74.50	73.67	76.00	98.00	98.00	13.69	15.50	15.08
21	74.50	72.25	74.17	65.50	97.00	98.00	10.36	14.27	15.33
28	78.50	72.50	74.50	61.50	98.00	98.00	11.02	14.53	15.50
Aug. 4	70.33	69.00	74.50	62.00	97.50	98.00	8.57	12.92	15.50
11	69.00	67.75	74.50	74.00	97.67	98.00	9.80	12.42	15.50
18	73.83	72.17	74.50	80.00	95.00	87.00	12.38	13.94	13.75
25	76.83	72.33	75.00	69.00	95.00	84.00	11.72	14.01	13.49
Sept. 1	77.83	72.83	75.00	70.00	97.00	83.00	12.29	14.54	13.32
8	82.50	75.25	75.00	64.00	98.00	84.40	13.03	15.86	13.55
15	74.50	70.83	75.17	66.00	98.00	86.00	10.44	13.78	13.88
22	61.00	66.25	75.50	78.00	97.00	87.00	7.94	11.75	14.19
29	57.67	62.50	75.50	64.00	97.00	89.67	5.73	10.38	14.62
Oct. 6	56.17	48.00	75.50	61.00	97.33	91.00	5.28	8.95	14.81
13	62.00	63.00	75.50	71.00	97.00	92.00	7.48	10.55	14.98
20	56.50	58.33	75.50	64.50	97.00	89.00	5.38	9.03	14.51
27	50.67	55.00	75.50	67.50	96.83	89.00	4.83	8.04	14.51
Nov. 3	46.17	54.17	75.50	69.00	96.83	91.67	4.37	8.09	14.92
10	48.50	53.00	75.50	68.00	96.80	93.60	4.51	7.50	15.24
17	46.25	53.50	75.50	68.00	97.00	94.00	4.16	8.01	15.31
24	46.00	49.50	75.50	62.50	96.67	96.00	4.09	6.63	15.65
Dec. 1	35.20	43.83	75.50	64.00	96.00	96.00	2.61	8.06	15.65
8	38.67	48.67	75.50	73.00	95.00	94.00	3.39	6.33	15.31
15	24.75	50.83	75.50	56.00	97.00	94.00	1.47	6.47	15.31
22	34.25	53.17	75.50	66.00	96.83	95.50	2.60	7.55	15.56
29	33.00	55.67	75.50	65.50	98.20	95.00	2.46	8.35	15.48
1913.									
Jan. 5	31.80	44.20	75.50	61.00	92.33	92.00	2.20	5.24	14.98
12	25.33	45.00	75.50	91.00	93.00	91.00	2.46	5.44	14.81
19	37.33	48.50	75.50	84.00	97.33	96.00	3.71	6.45	15.65
26	30.67	46.00	75.50	84.00	97.50	97.33	2.87	5.91	15.93
Feb. 2	26.33	43.00	75.33	71.00	97.00	98.50	2.00	5.28	15.83
9	15.00	40.67	75.50	74.50	97.33	95.67	1.26	4.86	15.59
16	25.83	40.00	75.50	69.00	96.00	97.00	1.85	4.68	15.82
23	42.00	45.83	75.50	72.00	96.00	98.00	3.78	5.78	15.98
Apr. 6	55.00	54.50	75.50	69.00	97.00	77.75	5.74	7.92	12.68
13	43.00	50.00	75.50	88.67	95.83	79.83	4.82	6.69	13.00
20	59.37	52.22	75.50	53.42	93.67	81.50	5.15	7.07	13.39
27	59.83	56.16	75.50	60.00	96.83	83.83	5.87	8.38	13.67

TABLE 6.—*Weekly averages of hygrometric records made in Illinois cooperative investigations—Continued.***ASSUMPTION NO. 1 MINE, ASSUMPTION COAL & MINING CO., CHRISTIAN COUNTY—Continued.**

Week ending—	Temperature.			Relative humidity.			Water in 100,000 cubic feet.		
	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.
1913.	° F.	° F.	° F.	Per cent.	Per cent.	Per cent.	Gallons.	Gallons.	Gallons.
May 4	64.37	56.00	75.50	46.67	97.17	87.50	5.30	8.32	14.27
11	58.00	57.67	75.50	53.00	97.00	89.33	4.88	8.80	14.57
18	67.17	60.22	76.00	61.50	97.00	93.50	7.68	9.55	15.74
25	62.33	61.01	76.00	63.50	95.33	93.17	6.75	9.71	15.43
June 1	74.00	62.33	76.00	67.10	96.40	95.40	10.42	10.37	15.81

EMPIRE NO. 2 MINE, CLARKE COAL & COKE CO., PEORIA, PEORIA COUNTY.

1912.									
Feb. 11	4.75	38.17	-----	74.50	87.00	-----	0.77	3.97	-----
25	37.00	46.25	63.50	74.00	88.00	97.00	3.23	4.77	10.73
Mar. 3	15.00	32.33	63.50	74.00	88.00	97.00	1.25	3.22	10.73
10	17.33	33.50	63.33	77.00	93.33	97.00	1.36	3.37	10.64
17	27.90	36.25	63.50	84.00	91.00	97.00	2.54	3.87	10.73
24	30.50	34.00	63.50	77.00	97.50	97.00	2.61	3.80	10.73
31	36.00	40.80	63.50	77.50	92.00	97.00	3.26	4.61	10.73
Sept. 29	50.00	54.75	65.33	75.00	74.50	97.00	5.23	6.13	11.40
Oct. 6	56.25	56.25	64.83	65.00	77.00	97.00	5.63	6.73	11.22
13	56.00	59.67	65.00	81.00	94.00	97.00	6.96	9.15	11.29
20	54.40	56.25	64.50	67.00	86.00	97.00	5.45	7.45	11.10
27	48.33	48.33	64.50	72.00	92.67	97.00	4.73	6.10	11.10
Nov. 3	44.50	48.00	64.00	70.00	94.00	97.00	4.02	6.12	10.92
10	45.60	47.33	63.89	68.00	96.00	97.00	4.06	6.04	10.88
17	42.00	44.62	63.83	72.00	96.00	97.00	3.78	5.54	10.86
24	43.75	42.67	63.33	63.00	96.00	97.00	3.52	5.35	10.64
Dec. 8	36.00	39.17	63.50	81.50	94.00	97.00	3.43	4.64	10.73
15	27.25	47.00	63.50	63.00	94.00	97.00	1.85	5.90	10.73
22	29.67	41.83	63.50	72.00	92.00	97.00	2.34	4.79	10.73
29	31.60	44.00	63.50	69.00	91.00	97.00	2.43	5.13	10.73
1913.									
Jan. 5	28.25	42.00	63.50	71.75	89.00	97.00	2.18	4.67	10.73
19	34.80	45.80	63.50	85.30	90.00	97.00	3.41	5.41	10.73
26	28.43	43.50	63.50	80.00	89.00	97.00	2.48	4.93	10.73
Feb. 2	25.40	40.20	63.50	76.60	89.00	98.00	1.75	4.37	10.84
9	15.88	36.50	63.50	70.00	93.00	97.00	1.23	3.99	10.73
Apr. 6	52.25	53.00	63.50	73.50	78.75	97.00	5.54	6.04	10.73
13	41.20	41.65	63.22	80.00	88.00	96.00	4.08	4.56	10.52
20	55.00	54.64	63.33	61.83	78.33	97.00	5.14	6.43	10.64
27	57.00	59.75	63.43	59.75	83.50	97.00	5.30	8.82	10.74
May 4	54.25	51.83	63.00	40.00	72.00	97.00	3.24	5.36	10.55

PEERLESS MINE, JONES & ADAMS COAL CO., SPRINGFIELD, SANGAMON COUNTY.

1912.									
Mar. 10	23.00	29.17	57.17	62.50	96.00	92.00	1.52	3.07	8.23
17	33.50	32.00	58.67	81.00	93.00	92.50	3.07	3.36	8.73
24	37.71	38.00	58.67	78.00	88.00	90.00	3.49	3.99	8.47
31	42.57	42.25	60.25	78.50	93.33	92.00	4.20	4.94	9.13
Apr. 7	50.00	45.50	59.00	65.00	93.00	94.00	4.54	5.54	8.94
14	49.00	44.33	59.33	94.00	94.00	95.00	6.34	5.36	9.14
21	51.33	55.50	60.33	67.00	94.00	99.00	4.90	7.94	9.85
28	57.50	59.67	60.50	60.00	94.00	97.00	5.43	9.15	9.71
July 28	76.00	74.67	70.33	57.00	94.50	98.00	9.44	15.01	13.56
Aug. 4	74.67	79.00	66.88	69.50	84.00	96.50	11.04	15.29	11.93
Sept. 1	74.50	74.25	67.12	67.00	94.50	95.00	10.50	14.82	11.85
Oct. 6	61.67	61.00	64.25	83.00	92.17	96.00	8.64	9.38	10.89
13	55.50	60.00	65.25	58.00	89.00	96.00	4.90	8.67	11.25
27	53.50	54.25	63.50	65.00	99.50	99.00	5.13	8.05	10.95
Nov. 3	60.25	60.00	62.50	59.00	100.00	100.00	5.86	9.84	10.90
Dec. 8	45.25	47.00	61.50	79.00	100.00	100.00	4.66	6.28	10.35
22	46.00	45.00	60.00	69.00	81.00	89.00	2.90	4.73	8.76
1913.									
Jan. 5	26.00	24.37	60.25	71.50	90.00	94.00	1.99	2.32	9.33
12	26.33	18.67	61.00	93.00	98.00	88.00	2.62	1.95	8.96
Feb. 16	28.00	36.00	63.00	65.00	84.00	83.50	1.97	3.53	9.08
23	45.25	46.75	61.50	74.50	87.00	93.00	4.39	5.42	9.59
Mar. 2	19.00	20.50	59.50	76.25	100.00	94.00	1.54	2.16	9.10
9	23.75	21.00	60.75	60.00	100.00	94.00	1.50	2.22	9.49

TABLE 6.—Weekly averages of hygrometric records made in Illinois cooperative investigations—Continued.

WOODSIDE MINE, WOODSIDE COAL CO., SPRINGFIELD, SANGAMON COUNTY.

Week ending—	Temperature.			Relative humidity. %			Water in 100,000 cubic feet.		
	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.
1912.	°F.	°F.	°F.	Per cent.	Per cent.	Per cent.	Gallons.	Gallons.	Gallons.
Feb. 25	28.00	44.37	59.37	76.50	78.00	80.50	2.33	4.46	7.76
Mar. 10	23.33	41.00	60.00	76.00	89.00	87.50	1.87	4.50	8.61
17	31.50	.....	60.00	83.00	.....	84.00	2.94	.....	8.27
24	34.00	.....	60.50	80.50	.....	85.00	3.14	.....	8.52
31	39.40	.....	61.00	78.50	.....	84.00	3.75	.....	8.55
Sept. 29	52.50	54.50	66.67	62.50	87.00	91.33	4.76	7.10	11.21
Oct. 6	56.17	54.67	66.00	61.00	88.00	94.00	5.27	7.23	11.29
13	61.00	59.33	66.00	68.00	89.00	95.00	6.92	8.56	11.41
20	56.50	55.00	66.00	61.50	84.00	95.33	5.38	6.98	11.45
27	50.67	50.67	65.50	67.50	82.00	95.17	4.82	5.86	11.25
Nov. 3	46.17	49.17	65.00	69.00	88.67	95.25	4.21	6.01	11.07
10	48.83	49.50	64.50	72.00	90.00	91.33	4.82	6.17	10.45
17	43.67	47.20	64.25	66.33	86.20	89.80	3.53	5.45	10.19
24	46.00	46.33	64.00	62.50	86.17	90.00	4.00	5.28	10.12
Dec. 1	35.20	37.80	63.20	64.00	81.00	90.00	2.61	3.65	9.86
8	38.67	42.25	63.00	73.00	87.00	90.00	3.39	4.46	9.79
15	26.50	32.20	62.20	51.00	87.00	90.00	1.45	3.17	9.66
22	35.20	37.40	62.00	67.00	83.00	90.20	2.73	3.68	9.49
29	35.00	36.50	62.00	62.00	81.00	92.00	2.51	3.47	9.68
1913.									
Jan. 5	31.80	36.33	62.00	61.00	83.40	93.00	2.19	3.55	9.79
12	25.33	32.50	61.50	91.00	88.17	94.00	2.45	3.25	9.73
19	37.33	37.17	61.75	84.00	91.00	93.00	3.71	3.99	9.61
26	30.67	35.17	61.83	84.00	88.00	94.00	2.87	3.59	9.84
Feb. 2	30.50	32.40	62.00	73.00	76.00	92.00	2.47	2.79	9.68
9	15.00	23.17	61.50	74.50	98.00	93.00	1.26	2.40	9.63
16	23.00	28.00	61.00	69.50	97.00	92.00	1.69	2.94	9.36
23	.....	41.33	61.00	.....	92.00	94.00	.....	4.71	9.57

M. & C. MINE, MANUFACTURERS AND CONSUMERS COAL CO., DECATUR, MACON COUNTY.

1912.									
Feb. 18	40.75	42.75	62.50	72.00	92.00	85.00	3.62	4.96	9.11
25	34.00	42.50	62.60	79.00	88.00	84.25	3.08	4.70	9.04
Mar. 3	21.00	34.67	62.50	69.50	89.50	87.33	1.16	3.58	9.34
10	26.00	35.87	62.25	80.50	93.00	89.00	2.24	3.89	9.44
17	31.50	41.17	63.00	83.00	90.67	92.00	2.94	4.62	10.01
24	36.00	43.25	63.25	81.00	92.00	93.50	3.41	5.05	10.26
31	40.25	44.25	63.25	80.00	94.00	95.00	3.95	5.35	10.42
Oct. 13	61.50	65.00	68.00	72.50	91.50	88.50	7.51	10.64	11.37
20	56.50	56.83	66.83	61.50	91.00	89.00	5.38	8.04	10.98
27	52.00	54.00	66.25	67.00	84.00	91.67	6.51	6.74	11.11
Nov. 3	46.17	53.00	66.33	69.00	81.50	88.00	4.20	6.32	10.69
10	48.50	50.60	66.33	68.00	82.00	89.83	4.50	5.84	10.91
17	46.25	50.00	66.17	68.00	82.83	93.00	4.16	5.78	11.24
24	46.00	28.33	65.83	62.50	78.00	91.33	4.00	5.14	10.91
Dec. 1	35.20	42.00	65.00	64.00	82.33	91.00	2.61	4.32	10.58
8	38.67	47.50	65.00	73.00	86.00	89.67	3.33	5.50	10.42
15	31.67	40.00	65.00	54.00	82.00	95.00	1.93	4.00	11.04
22	34.25	42.50	65.00	66.00	87.00	95.00	2.60	4.65	11.04
29	33.00	41.00	65.00	65.50	84.00	95.00	2.46	4.25	11.04
1913.									
Jan. 5	31.80	42.50	65.00	61.00	85.00	95.00	2.19	4.54	11.04
12	26.40	39.50	65.00	91.00	89.00	95.00	3.75	4.26	11.04
19	37.33	41.25	65.00	83.50	89.33	95.00	3.68	4.56	11.04
26	23.00	38.00	65.00	83.50	89.50	95.00	2.03	4.05	11.04

TABLE 6. —Weekly averages of hygrometric records made in Illinois cooperative investigations—Continued.

MINE NO. 3, SALINE COUNTY COAL CO., HARRISBURG, SALINE COUNTY.

Week ending	Temperature.			Relative humidity.			Water in 100,000 cubic feet.		
	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.
	° F.	° F.	° F.	Per cent.	Per cent.	Per cent.	Gallons.	Gallons.	Gallons.
1912.									
Feb. 18	33.83	51.58	51.58	93.00	87.83	87.83	3.61	3.61	5.74
25	37.75	52.75	52.75	93.66	94.00	94.00	4.20	4.20	7.22
Mar. 3	33.50	52.33	52.33	94.00	94.16	94.16	3.60	3.60	7.13
10	33.50	51.53	51.53	98.50	93.16	93.16	3.77	3.77	6.81
17	38.16	52.50	52.50	95.66	97.00	97.00	4.36	4.36	7.39
24	46.00	54.50	54.50	92.33	97.33	97.33	5.59	5.59	7.95
31	49.00	54.67	54.67	92.33	95.50	95.50	6.22	6.22	7.82
Apr. 7	64.50	58.56	55.83	59.00	90.33	98.00	6.75	8.75	8.37
14	61.30	57.06	56.33	60.00	61.00	96.80	6.17	8.11	8.41
21	49.67	56.50	56.50			91.00		5.87	7.96
28	60.75	58.08	57.22	61.00	84.00	94.50	6.16	7.61	8.47
May 5	65.75	63.89	57.92	81.00	89.17	96.17	9.65	9.99	8.82
12	70.50	68.44	59.11	71.00	83.00	97.00	9.97	10.80	9.26
19	62.80	60.83	59.00	69.00	86.20	99.20	7.46	8.72	9.44
26	76.70	71.60	59.90	61.00	85.20	99.20	10.33	12.28	9.73
June 2	72.88	73.67	61.17	73.00	86.00	99.50	10.96	13.06	10.23
9	71.70	69.00	61.00	65.00	84.00	98.80	9.40	11.09	10.06
16	71.83	71.58	60.83	68.00	80.33	99.00	9.85	12.00	10.02
23	65.25	67.17	62.33	86.00	91.67	99.00	10.08	11.45	10.54
30	68.00	70.67	62.17	85.00	93.00	99.50	10.91	13.01	10.51
July 7	74.62	75.50	63.75	88.00	96.00	99.50	13.96	15.66	11.10
14	77.50	77.50	64.83	83.00	95.50	100.00	14.42	16.59	11.56
21	75.17	77.56	66.00	82.00	96.00	99.00	13.22	16.70	11.89
28	78.08	78.83	66.11	77.00	86.50	99.00	13.60	15.67	11.92
Aug. 4	71.88	72.08	65.63	74.00	86.00	99.50	10.76	12.58	11.81
11	68.21	71.33	64.07	78.00	92.00	98.29	10.06	13.14	11.08
18	75.50	65.11	65.50	85.00	94.00	99.67	13.91	10.97	11.78
25	74.17	75.14	66.78	84.00	92.67	100.00	13.13	15.54	12.32
Sept. 1	75.50	78.60	66.93	79.00	90.00	100.00	12.89	16.18	12.39
8	78.75	78.42	67.83	75.00	89.00	98.00	13.54	15.91	12.50
15	71.45	74.40	67.30	73.00	89.60	99.60	10.46	14.12	12.49
22	62.88	66.67	64.83	83.00	90.50	99.00	8.99	11.12	11.44
29	49.58	58.33	63.44	79.00	83.67	99.33	6.42	8.88	10.97
Oct. 6	54.92	61.50	63.61	80.00	85.33	97.00	6.63	8.83	10.77
13	66.69	70.58	63.08	76.00	78.75	99.00	9.34	10.78	10.80
20	44.38	59.17	63.00	78.00	89.00	100.00	4.46	8.52	10.88
27	49.40	55.30	63.00	78.00	86.00	98.00	5.33	7.21	10.65
Nov. 3	47.13	54.17	63.08	77.00	84.00	98.33	4.85	6.78	10.72
10	49.19	52.50	62.88	70.00	82.50	98.00	4.75	6.29	10.62
17	35.13	45.50	60.42	68.50	70.00	96.00	2.79	4.17	9.58
24	45.75	54.83	60.50	61.00	94.33	94.83	3.66	7.77	9.34
Dec. 1	36.62	46.58	59.83	67.00	94.00	93.00	2.88	5.87	9.11
8	41.50	49.80	60.00	80.00	91.00	95.00	4.12	6.31	9.35
15	27.75	38.50	59.89	63.00	86.50	94.00	1.89	3.99	9.22
22	34.50	42.28	60.00	76.00	81.50	94.00	3.02	4.32	9.25
29	29.83	38.78	59.00	72.33	84.00	94.00	2.39	3.92	8.94

EQUALITY MINE, GALLATIN COAL & COKE CO., GALLATIN COUNTY.

1912.									
Sept. 29	53.50	64.50	64.50	81.00	90.40	95.40	6.39	10.34	10.91
Oct. 6	54.91	64.67	64.08	80.00	90.67	96.67	6.63	10.43	10.91
13	64.91	68.00	65.08	72.00	89.00	96.00	8.35	11.41	11.19
20	52.75	63.00	63.00	78.50	88.50	96.00	5.93	9.63	10.45
27	47.63	59.25	64.00	79.00	89.00	99.00	5.06	8.52	11.14
Nov. 3	47.13	57.25	63.75	77.00	97.00	97.00	4.84	8.70	10.82
10	47.91	57.30	63.83	68.00	98.00	97.00	4.41	8.80	10.85
17	44.25	56.50	64.00	77.00	88.67	97.67	4.38	7.75	10.99
24	45.75	55.40	63.61	61.00	78.00	96.00	3.66	6.57	10.65
Dec. 1	35.90	49.80	62.83	66.00	76.00	95.60	2.76	5.27	10.34
15	27.75	45.00	60.92	63.00	76.00	98.00	1.89	4.44	9.95
22	34.50	48.50	62.08	76.00	79.00	98.00	3.02	5.23	10.34
29	31.05	47.30	61.40	73.00	79.00	98.00	2.53	5.01	10.11

TABLE 6.—*Weekly averages of hygrometric records made in Illinois cooperative investigations—Continued.*

EQUALITY MINE, GALLATIN COAL & COKE CO., GALLATIN COUNTY—Continued.

Week ending—	Temperature.			Relative humidity.			Water in 100,000 cubic feet.		
	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.
1913.	° F.	° F.	° F.	Per cent.	Per cent.	Per cent.	Gallons.	Gallons.	Gallons.
Jan. 5	34.91	48.75	61.50	70.00	83.00	95.00	2.83	5.54	9.83
12	30.10	46.08	62.60	91.00	87.00	97.00	3.01	5.29	10.42
19	40.91	50.83	62.56	84.67	88.00	96.00	4.37	6.32	10.30
26	37.08	51.91	61.83	83.00	93.00	97.00	3.63	6.94	10.15
Feb. 2	31.17	50.78	61.39	71.00	89.00	96.00	2.48	6.38	9.90
9	18.00	44.33	60.50	66.67	85.00	94.00	1.28	4.85	9.41
16	30.33	46.33	58.94	56.33	87.00	95.00	1.89	5.33	9.02
23	44.67	54.67	61.22	77.33	91.00	95.67	4.47	7.47	9.82
Mar. 2	31.40	47.43	58.47	86.00	87.00	96.00	3.03	5.55	8.97
9	34.50	49.67	59.22	73.50	82.00	95.33	2.92	5.66	9.14
16	45.50	55.45	59.67	75.00	90.00	96.00	4.47	7.59	9.35
23	45.75	55.83	58.83	75.33	90.00	94.50	4.51	7.69	8.94
30	55.50	54.83	58.75	95.50	89.50	93.50	8.07	7.39	8.68

HART & WILLIAMS NO. 1 MINE, HART & WILLIAMS COAL CO., FRANKLIN COUNTY.

1912.									
Feb. 11	26.00	60.33	97.00	85.00	2.70	8.46			
18	34.50	60.83	91.50	90.00	3.64	9.11			
25	38.50	61.50	98.00	92.00	4.52	9.52			
Mar. 3	33.00	61.00	95.00	90.00	3.57	9.16			
10	33.50	60.50	99.00	91.00	3.79	9.11			
17	40.00	61.00	100.00	92.00	4.88	9.36			
24	44.00	61.50	99.00	92.00	5.58	9.52			
31	48.67	62.00	99.50	89.33	6.63	9.40			
June 9	74.67	65.83	66.00	63.00	98.33	99.50	10.01	11.75	11.95
16	71.50	76.33	66.50	74.00	99.00	99.33	10.63	16.58	12.12
23	62.00	69.33	66.33	85.00	99.00	99.75	9.00	13.26	12.11
30	68.00	74.13	66.63	85.00	93.33	100.00	10.91	15.51	12.27
July 7	74.67	79.50	67.75	86.00	100.00	100.00	13.66	18.49	12.72
14	77.40	81.50	69.00	84.00	100.00	100.00	14.54	19.97	13.25
21	75.60	80.20	69.20	80.00	99.20	100.00	13.09	18.73	13.34
28	78.33	82.63	68.75	76.00	100.00	100.00	13.54	20.36	13.38
Aug. 4	71.75	75.40	69.00	72.00	99.33	100.00	10.42	16.15	13.25
11	67.75	75.25	68.50	83.00	100.00	100.00	10.47	16.18	13.04
18	76.75	83.25	70.13	86.50	100.00	100.00	14.67	20.75	13.74
Sept. 22	62.67	68.00	68.67	84.00	99.33	100.00	9.04	12.74	13.11
29	51.75	60.14	68.00	81.00	100.00	100.00	6.01	9.89	12.82
Oct. 6	56.33	60.56	66.25	79.00	99.28	99.56	6.86	9.96	12.06
13	64.50	64.50	67.50	70.00	99.67	99.50	8.00	11.40	12.56
20	52.67	57.00	67.00	79.00	100.00	100.00	6.04	8.89	12.42
27	47.50	57.33	66.67	78.00	99.83	100.00	4.99	8.98	12.28
Nov. 3	44.50	50.00	66.00	78.00	100.00	100.00	4.48	6.98	12.02
10	53.83	62.00	65.83	76.00	100.00	100.00	6.06	10.53	11.95
17	38.00	53.33	65.50	70.00	96.00	95.67	3.17	7.53	11.31
24	45.75	54.25	65.50	61.00	97.00	98.50	3.66	7.83	11.64
Dec. 1	36.00	42.67	63.33	66.00	100.00	99.00	2.78	5.37	10.89
8	41.75	45.50	63.75	85.00	100.00	100.00	4.42	5.95	11.16
15	33.00	37.80	63.33	62.00	99.33	100.00	2.33	4.47	11.00
22	33.00	41.47	64.00	75.00	100.00	100.00	2.82	5.15	11.25
29	33.00	38.00	63.50	77.00	100.00	99.00	2.89	4.53	10.95
1913.									
Jan. 5	34.00	38.75	64.83	76.00	98.67	99.25	2.97	4.60	11.47
12	33.00	36.00	63.00	89.00	100.00	100.00	3.34	4.21	10.88
19	41.50	46.50	63.50	86.33	100.00	100.00	4.45	6.17	11.07
26	37.33	41.00	64.00	85.00	100.00	99.40	3.76	5.06	11.18
Feb. 2	31.17	37.67	63.50	71.00	99.50	99.67	2.48	4.45	10.97
9	12.75	25.50	61.00	73.50	100.00	89.00	1.12	2.72	9.06
Apr. 20	58.14	57.78	64.22	60.28	89.42	97.50	5.58	8.18	11.24
27	60.33	63.33	65.13	67.00	97.33	96.33	6.67	10.71	11.25
May 4	63.00	62.33	65.17	58.33	94.50	99.17	6.35	10.06	11.59
11	58.71	60.07	64.95	58.56	99.70	99.70	5.45	9.84	11.58
18	68.80	70.30	66.44	74.00	94.00	100.00	9.74	12.99	12.21
25	61.17	52.43	66.72	68.50	100.00	99.67	7.01	7.55	12.28
June 1	74.08	67.08	67.13	71.83	99.00	99.67	11.20	12.30	12.38

TABLE 6.—Weekly averages of hygrometric records made in Illinois cooperative investigations—Continued.

BIG MUDDY MINE, CHICAGO & BIG MUDDY COAL CO., WILLIAMSON COUNTY.

Week ending—	Temperature. ^a			Relative humidity. ^a			Water in 100,000 cubic feet.		
	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.
	° F.	° F.	° F.	Per cent.	Per cent.	Per cent.	Gallons.	Gallons.	Gallons.
1912.									
Oct. 6	63.17	71.17	73.50	77.00	75.00	76.00	8.31	10.66	11.63
13	64.92	67.00	77.75	72.00	86.67	89.67	8.35	10.76	15.70
20	52.75	57.17	78.08	78.08	91.00	96.67	5.93	8.14	17.10
27	47.62	52.42	77.83	79.00	93.50	96.67	5.06	7.09	16.96
Nov. 3	47.12	56.67	77.67	77.00	95.33	96.67	4.84	8.38	16.88
10	47.88	51.42	77.50	68.00	100.00	100.00	4.39	7.34	17.37
17	44.25	49.67	77.58	77.00	94.67	100.00	4.38	6.53	17.41
24	45.75	47.00	76.75	61.00	100.00	100.00	3.66	6.28	16.95
Dec. 1	35.90	39.40	76.25	66.00	100.00	100.00	2.76	4.77	16.70
8	44.83	46.00	76.50	74.67	96.00	100.00	4.46	5.82	16.83
15	27.75	31.67	75.50	63.00	100.00	100.00	1.89	3.57	16.31
22	34.50	38.75	76.00	76.00	85.00	100.00	3.02	3.89	16.57
29	30.10	36.00	75.00	75.40	87.00	95.00	2.51	3.66	15.25
1913.									
Jan. 5	33.45	40.40	76.75	71.00	86.00	97.00	2.71	4.32	16.46
12	30.00	36.13	75.75	91.00	91.00	97.00	2.99	3.84	15.94
19	40.92	41.17	76.08	84.67	92.00	97.50	4.37	4.68	16.19
Feb. 26	37.08	41.50	75.75	83.00	93.00	98.00	3.63	4.79	16.31
9	31.17	37.17	76.00	71.00	92.00	98.00	2.48	4.04	16.24
16	18.00	27.00	75.00	66.67	91.00	97.00	1.28	2.64	15.57
Mar. 2	26.90	30.75	75.00	66.80	85.00	98.00	1.93	2.91	15.73
9	25.50	31.50	76.00	87.00	89.00	99.00	2.36	3.15	16.40
16	33.10	35.35	76.80	76.80	92.00	91.80	2.90	3.78	15.60
23	45.50	46.13	76.46	75.00	87.00	97.00	4.47	5.29	15.89
Apr. 6	45.75	43.33	77.42	75.33	90.33	96.33	4.51	4.96	16.69
13	56.38	47.50	79.25	45.25	87.50	95.50	3.94	5.59	17.52
20	49.75	49.25	78.50	84.33	93.67	98.17	5.83	6.37	17.59
27	59.08	52.11	78.50	60.50	93.33	100.00	5.97	7.52	17.92
May 4	60.33	54.92	78.50	67.00	96.00	99.00	6.67	7.96	17.25
	55.17	51.67	79.33	60.33	95.67	100.00	5.04	7.04	18.39

MINE NO. 3, SUPERIOR COAL CO., MACOUPIN COUNTY.

1912.									
Feb. 18	44.00	39.83	50.17	67.50	95.50	93.50	3.81	4.63	6.56
25	34.86	35.00	51.72	77.72	92.00	94.00	3.13	3.73	6.97
Mar. 3	29.33	32.67	52.55	73.00	92.00	94.00	2.35	3.41	7.17
17	31.00	35.33	51.33	95.00	91.00	94.00	3.29	3.73	6.88
July 7	80.00	75.50	74.00	78.00	96.00	98.00	14.64	15.66	15.24
14	79.50	81.33	67.25	73.25	95.00	95.75	13.54	18.59	11.99
Oct. 6	69.67	68.00	64.33	58.00	99.00	91.67	7.85	12.70	10.43
13	67.60	68.80	65.33	66.00	100.00	95.33	8.41	13.16	11.20
20	62.75	65.42	64.56	60.50	95.00	94.00	6.53	11.20	10.77
27	52.50	57.37	64.00	58.25	95.50	84.00	4.44	8.60	9.45
Nov. 3	40.33	48.80	62.17	73.33	98.00	85.67	4.06	6.81	9.07
10	50.00	60.42	63.17	75.00	98.50	90.50	5.23	9.83	9.90
17	46.00	50.00	63.00	74.00	100.00	85.00	4.48	6.98	9.25
24	55.67	53.67	61.83	49.00	99.33	89.33	4.12	8.16	9.35
1913.									
Jan. 5	40.50	47.50	57.96	50.00	92.00	93.00	2.48	5.83	8.48
12	26.00	46.00	56.00	89.67	93.00	92.67	2.49	5.63	7.96
19	36.00	41.33	56.83	75.50	91.50	92.00	3.18	5.22	8.13
26	37.33	41.67	57.00	81.33	94.00	94.00	3.60	5.43	8.36
Feb. 2	20.00	41.33	58.33	58.00	91.00	89.00	1.23	4.66	8.28
Apr. 6	57.33	60.67	58.92	62.83	96.00	94.33	5.65	9.66	8.95
13	46.00	48.00	59.57	83.00	99.43	94.28	5.03	6.47	9.15
20	59.86	60.73	58.81	52.57	99.43	97.00	5.15	10.03	9.17
27	67.00	62.22	59.67	49.67	98.67	98.00	6.10	10.46	9.54

MINE NO. 2, MADISON COAL CORPORATION, GLEN CARBON, MADISON COUNTY.

1912.									
Mar. 3	26.00	32.53	65.50	64.50	84.00	92.00	1.79	3.10	10.87
10	27.40	33.00	65.50	78.20	85.00	92.00	2.32	3.19	10.87
17	33.67	35.78	65.46	80.00	87.00	93.00	3.08	3.63	10.97
24	39.33	39.67	65.39	80.00	88.00	93.00	3.83	4.27	10.95
31	42.80	42.60	65.42	79.40	88.00	93.00	4.29	4.72	10.96

^a In the Big Muddy mine, the temperature and relative humidity at the return shaft was higher than normal because of heat radiating from uncovered steam pipes along the main entry and because of exhaust steam from pumps.

TABLE 6.—Weekly averages of hygrometric records made in Illinois cooperative investigations—Continued.

MINE NO. 2, MADISON COAL CORPORATION, GLEN CARBON, MADISON COUNTY—Contd.

Week ending—	Temperature.			Relative humidity.			Water in 100,000 cubic feet.		
	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.
1912.	° F.	° F.	° F.	Per cent.	Per cent.	Per cent.	Gallons.	Gallons.	Gallons.
May 19	57.67	62.00	68.67	64.33	70.00	94.33	5.85	7.37	12.36
26	74.84	77.17	68.67	60.33	65.00	94.33	9.63	11.17	12.36
June 2	70.60	73.07	68.93	68.00	78.00	94.00	9.50	11.77	12.43
9	68.20	72.50	68.50	62.00	67.00	95.00	7.99	10.16	12.38
16	73.50	76.00	68.67	64.50	76.67	94.50	9.88	12.70	12.38
23	64.67	68.58	68.83	76.00	78.00	94.00	7.59	10.19	12.39
30	76.00	77.33	69.08	68.50	70.00	91.00	11.35	12.10	12.49
July 7	75.33	76.67	69.00	83.67	77.67	95.67	13.48	13.11	12.67
28	81.60	82.67	68.67	68.60	72.00	95.00	12.53	14.48	12.45
Aug. 4	75.40	77.60	69.10	57.60	64.00	95.00	9.37	11.33	12.63
11	71.17	73.45	69.28	72.50	73.50	95.00	10.30	11.24	12.70
18	77.33	78.22	69.83	77.00	83.00	95.67	13.01	14.74	13.12
25	79.00	80.67	70.50	66.67	75.00	95.33	12.13	14.38	13.26
Sept. 1	80.33	84.00	70.56	69.33	70.00	94.00	13.06	14.86	13.10
8	85.40	84.60	71.00	57.40	68.00	95.60	12.72	14.70	13.51
15	78.80	79.13	70.87	60.60	66.60	95.00	10.88	12.17	13.37
29	60.25	62.25	70.33	62.00	72.00	95.00	6.15	7.64	13.14
Oct. 6	65.60	66.93	69.90	56.80	67.00	95.60	6.73	8.30	13.04
13	68.40	70.10	70.10	66.40	75.00	96.67	8.63	10.30	13.27
20	61.00	62.47	69.78	56.67	72.67	98.00	5.73	8.20	13.31
27	54.00	55.19	69.28	59.50	77.33	94.75	4.78	6.46	12.67
Nov. 3	47.00	52.83	68.83	64.17	75.33	94.33	4.03	5.81	12.43
10	52.60	52.20	68.50	68.60	84.60	94.40	5.24	6.38	12.31
17	50.33	53.50	68.67	72.00	71.50	94.50	5.09	5.64	12.38
24	52.17	52.00	68.25	56.33	71.00	94.67	4.24	5.32	12.24
Dec. 1	38.60	44.60	67.17	61.18	80.00	95.40	2.86	4.61	11.95
8	42.33	43.83	67.50	65.67	85.00	95.50	3.48	4.76	12.05
15	32.17	37.02	66.89	50.17	76.00	95.00	1.86	3.32	11.75
22	38.33	39.75	66.67	62.17	80.00	95.00	2.83	3.87	11.67
29	38.00	39.69	66.07	61.00	79.40	95.60	2.76	3.82	11.51
1913.									
Jan. 5	40.00	40.50	66.60	50.20	87.00	95.00	2.46	4.32	11.64
12	26.00	35.42	65.83	89.67	91.00	96.00	2.49	3.73	11.47
19	43.50	43.22	66.11	77.00	87.50	95.50	4.27	4.80	11.52
26	35.50	37.67	66.00	81.33	91.00	95.00	3.36	4.07	11.41
Feb. 2	30.33	35.92	66.00	65.67	80.00	95.00	2.21	3.72	11.41
9	21.33	25.32	65.33	68.67	85.00	95.00	1.54	2.35	11.17
16	31.67	33.06	65.67	64.00	88.00	94.00	2.28	3.31	11.17
23	49.33	48.25	66.17	66.67	87.00	95.00	4.53	5.71	11.48
Mar. 2	31.25	35.33	65.67	62.17	88.50	95.25	2.17	3.75	11.24
Apr. 6	60.50	61.33	67.00	62.25	83.30	96.25	6.23	8.91	11.94
13	46.33	50.11	67.17	83.67	88.67	94.83	5.13	6.21	11.84
20	60.83	60.67	67.45	53.83	81.50	94.83	5.45	8.21	11.94
27	61.00	63.28	68.39	64.17	80.67	94.83	6.53	8.86	12.30
May 4	66.17	67.39	68.25	48.50	66.67	95.00	5.86	8.37	12.28
11	58.80	63.07	68.67	51.00	76.20	95.00	4.84	8.31	12.45
18	68.00	68.08	68.92	50.50	82.50	95.00	6.44	10.61	12.55

LUMAGHI NO. 2 MINE, LUMAGHI COAL CO., COLLINSVILLE, MADISON COUNTY.

1912.									
Apr. 14	58.00	62.00	63.00	48.00	79.00	83.00	4.42	8.31	9.03
21	49.00	53.40	62.00	73.00	92.40	91.40	4.77	7.23	9.62
28	61.17	56.50	62.00	67.67	86.00	90.67	7.26	7.52	9.54
May 5	65.67	60.58	62.83	75.33	90.00	92.00	8.96	9.06	9.96
12	73.00	67.00	63.00	70.50	93.00	93.50	10.62	11.55	10.17
19	57.67	59.00	63.70	64.33	88.00	95.00	5.85	8.37	10.57
26	74.60	71.90	64.70	63.40	91.00	96.00	10.05	13.23	11.05
June 2	67.17	69.50	65.92	70.00	91.00	95.33	11.71	12.25	11.42
9	66.67	68.00	65.58	60.33	89.50	96.33	7.41	11.48	11.41
16	73.00	71.00	65.30	67.60	92.00	96.60	10.18	13.00	11.77
23	64.67	68.33	66.67	76.00	94.50	95.33	7.59	12.25	11.58
30	75.60	72.40	66.40	67.60	93.00	95.00	11.06	13.74	11.57
July 7	79.00	76.75	64.75	78.25	93.00	96.50	14.24	15.77	11.13
14	79.67	78.25	68.83	73.17	95.00	96.00	13.57	16.90	12.65
21	75.67	77.92	69.25	77.50	93.67	98.33	12.80	16.48	13.04
28	80.67	79.50	69.42	67.92	94.33	98.00	13.53	17.42	13.17
Aug. 4	73.33	74.50	68.75	58.67	95.67	98.00	8.94	15.12	12.67
11	71.17	74.00	68.00	72.50	94.33	98.00	10.30	14.67	12.57
18	77.33	76.00	68.75	77.00	96.33	98.50	13.01	15.96	12.95
25	79.00	78.25	70.00	66.67	94.00	98.00	12.13	16.72	13.41

TABLE 6.—*Weekly averages of hygrometric records made in Illinois cooperative investigations—Continued.*

LUMAGHI NO. 2 MINE, LUMAGHI COAL CO., COLLINSVILLE, MADISON COUNTY—Contd.

Week ending—	Temperature.			Relative humidity.			Water in 100,000 cubic feet.		
	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.	Outside air.	Intake air.	Return air.
1912.	° F.	° F.	° F.	Per cent.	Per cent.	Per cent.	Gallons.	Gallons.	Gallons.
Sept. 1	80.33	79.25	69.67	69.33	96.00	98.00	13.06	17.61	13.27
8	85.40	77.20	74.40	57.40	96.80	95.40	12.72	16.66	15.03
15	77.67	70.00	70.00	60.00	91.00	97.67	10.48	15.56	13.38
22	66.25	76.25	69.38	78.25	92.75	96.00	9.48	15.49	12.88
29	56.33	62.00	67.00	56.00	90.00	98.00	4.87	9.47	12.17
Oct. 6	63.50	63.25	67.00	56.33	90.50	96.33	6.73	9.93	11.96
13	66.33	65.42	66.42	65.33	94.00	96.50	7.94	11.08	11.75
20	57.50	62.00	66.00	46.00	90.00	95.00	4.18	9.47	11.41
27	58.00	59.00	64.50	56.00	91.00	95.00	5.15	8.66	10.87
Nov. 24	54.00	56.00	62.50	62.00	91.00	86.00	4.97	7.82	9.20
Dec. 1	43.00	48.00	62.00	66.00	86.00	89.00	3.59	5.48	9.37
8	42.33	51.25	64.00	65.67	91.00	90.00	3.48	6.55	10.12
15	32.17	39.20	60.50	50.17	88.00	95.00	1.86	4.17	9.51
22	38.33	45.00	60.58	62.17	88.00	94.00	2.83	5.14	9.44
29	38.00	43.75	60.00	57.50	86.50	94.00	2.58	4.83	9.25
1913.									
Jan. 5	39.25	42.75	60.00	50.75	86.00	94.00	2.41	4.63	9.25
12	27.20	39.40	59.60	91.60	90.00	95.00	2.68	4.29	9.23
19	43.50	45.25	59.50	77.00	93.00	96.00	4.27	5.49	9.29
26	42.75	42.50	61.00	85.25	91.00	94.00	4.59	4.95	9.57
Feb. 2	30.33	42.33	60.00	65.67	91.00	94.00	2.21	4.83	9.25
9	21.33	30.50	58.50	38.67	96.00	94.00	1.54	3.25	8.80
16	31.67	36.67	58.00	64.00	90.00	94.00	2.28	3.88	8.65
23	49.60	37.70	59.00	63.40	91.00	94.00	4.36	4.08	8.95
Mar. 2	28.17	38.67	58.75	77.00	89.00	95.50	2.36	4.13	9.01
9	37.67	41.25	58.17	60.67	90.50	94.50	2.71	4.63	8.44
16	48.40	50.50	59.30	72.40	93.40	93.40	4.60	6.60	8.98
23	28.17	46.75	59.42	82.67	87.33	94.00	2.53	5.43	9.07
30	44.25	48.25	60.00	86.50	89.25	94.00	4.88	5.93	9.25
Apr. 6	57.20	53.70	60.70	62.00	89.00	92.40	5.55	7.56	9.31
13	46.40	53.00	60.80	85.80	91.20	90.00	5.27	7.07	9.10
20	60.83	58.10	61.30	53.67	89.60	89.00	5.45	8.22	9.15
27	61.00	61.75	61.83	64.17	90.17	91.50	6.53	9.41	9.57
May 4	68.00	62.50	62.87	49.00	89.00	89.75	6.28	9.52	9.72
11	62.60	63.40	63.40	52.20	86.20	89.80	5.61	9.50	9.90

MINE NO. 5, CENTRALIA COAL CO., MARION COUNTY.

1912.									
Feb. 18	46.00	46.00	61.67	63.00	79.00	89.00	3.81	4.79	9.26
25	34.33	39.00	57.92	74.83	89.00	91.00	2.96	4.18	8.34
Mar. 3	25.83	34.00	59.22	70.83	95.00	90.00	1.94	3.61	8.84
10	26.67	36.00	57.64	79.50	93.00	88.00	2.27	3.91	8.00
17	33.67	38.67	60.89	80.00	91.50	88.00	3.08	4.25	8.93
24	39.33	44.39	62.30	80.33	87.00	86.00	3.87	4.98	9.14
31	44.50	48.75	63.00	78.67	90.67	86.00	4.52	6.46	9.36
May 12	65.00	69.00	68.00	76.50	96.00	85.00	8.89	12.72	10.91
19	56.00	60.00	67.55	65.40	83.00	85.00	5.62	8.17	10.67
26	74.83	76.00	68.25	60.33	64.00	87.00	9.63	10.60	11.25
June 2	70.60	74.66	68.66	68.00	80.00	88.60	9.50	12.71	11.60
9	66.75	74.00	68.25	63.50	63.75	88.75	7.72	9.92	11.48
16	73.80	78.17	68.60	68.40	62.00	87.00	10.58	11.00	11.38
23	64.67	70.00	68.78	76.00	75.00	89.00	7.59	10.26	11.82
30	75.80	77.50	68.70	68.00	65.00	86.00	11.19	11.29	11.41
July 21	75.00	81.00	69.20	78.40	76.00	95.00	12.58	14.84	12.67
28	81.60	83.33	69.25	68.60	69.00	96.00	13.53	14.36	12.82
Aug. 4	73.33	76.00	68.75	58.67	68.00	94.00	8.94	11.27	12.20
11	71.17	75.33	68.35	72.50	76.00	93.00	10.30	12.33	12.06
18	77.33	80.33	69.00	77.00	92.00	94.00	13.01	17.45	12.46
Sept. 1	79.00	81.00	69.55	66.67	79.67	95.00	12.13	15.42	12.81
8	80.33	84.17	69.33	69.33	73.00	94.83	13.06	16.66	12.70
15	85.40	87.40	69.80	57.40	80.60	95.00	12.72	18.97	12.91
22	77.67	82.11	69.50	60.00	91.00	94.00	10.48	18.24	12.66
29	63.83	70.50	69.00	80.00	88.67	93.00	8.95	12.33	12.32
Oct. 6	59.67	65.17	68.05	59.50	81.00	90.50	5.79	9.47	11.62
13	63.50	67.42	67.42	56.33	75.50	88.00	6.73	9.50	11.08
20	66.33	72.33	68.17	65.33	75.00	87.67	7.94	11.06	11.54
27	61.00	65.56	67.92	56.33	73.00	87.00	5.67	8.64	11.13

DISCUSSION OF HYGROMETRIC RECORDS.

Comments on the records contained in Table 6 and deductions from them are given below.

TEMPERATURE AND RELATIVE HUMIDITY OF OUTSIDE AIR DURING PERIOD OF TESTS.

During the year February 1, 1912, to January 31, 1913, the total range of temperature and the maximum and minimum temperatures at two Illinois weather-bureau stations were as shown below:

Annual temperature range at two stations.

Weather-bureau station.	Maximum temperature.		Minimum temperature.		Total annual range.
	° F.	Date.	° F.	Date.	° F.
LaSalle.....	97	Sept. 8, 1912	-7	Feb. 4, 1912	104
Springfield.....	96	do.....	-9	do.....	105

The mean monthly temperatures for the same period were as given below:

Mean monthly temperatures during period of tests.

Date.	Temperature at LaSalle weather-bureau station.	Temperature at Springfield weather-bureau station.	Date.	Temperature at LaSalle weather-bureau station.	Temperature at Springfield weather-bureau station.
1912.	° F.	° F.	1912.	° F.	° F.
February.....	20.4	24.6	September.....	66.0	68.2
March.....	28.0	32.1	October.....	53.7	57.0
April.....	50.7	54.3	November.....	41.8	43.4
May.....	64.1	66.4	December.....	32.6	34.6
June.....	68.1	69.8			
July.....	74.6	77.1	1913.		
August.....	70.8	73.9	January.....	27.6	30.8

The mean annual temperature during 1912 in each county in Illinois that produces coal is given below:

Mean annual temperature of counties producing coal.

Name and County.	Mean annual temperature for 1912.	Name of County.	Mean annual temperature for 1912.
	° F.		° F.
Bureau, Grundy, Henry, LaSalle, Rock Island, Will.....	48	Calhoun, Christian, Green, Macoupin, Montgomery, Scott, Shelby.....	52
Livingston, Marshall, Mercer, Peoria, Putnam, Stark, Warren.....	49	Bond, Jefferson, Jersey, Marion.....	53
Fulton, Hancock, McDonough, McLean, Tazewell, Vermilion, Woodford.....	50	Clinton, Franklin, Madison, St. Clair, Washington, Williamson.....	54
Brown, Edgar, Logan, Macon, Menard, Moultrie, Sangamon, Schuyler.....	51	Jackson, Perry, Randolph, Saline.....	55
		Gallatin.....	56

The average maximum and minimum daily temperatures and the average daily range in temperature at the La Salle weather bureau station for the 12 months beginning February, 1912, are below:

Average daily temperature, by months, at La Salle station.

Month.	Average daily temperature.			Month.	Average daily temperature.		
	Maxi- mum.	Mini- mum.	Range.		Maxi- mum.	Mini- mum.	Range.
1912.	° F.	° F.	° F.	October.....	° F.	° F.	° F.
February.....	26.9	13.6	13.3	November.....	65.3	42.7	22.6
March.....	35.8	20.0	15.8	December.....	50.7	33.0	17.7
April.....	60.6	40.7	19.9		40.5	24.4	16.1
May.....	74.8	53.1	21.7	1913.			
June.....	79.7	56.7	23.0	January.....	35.5	19.0	16.5
July.....	85.5	63.4	22.1	Average.....			18.9
August.....	80.8	61.4	18.4				
September.....	76.6	56.4	20.2				

It is significant that the greatest diurnal range in temperature occurred in the spring and autumn seasons and coincides with the period of the greatest frequency of roof falls in the mines.

In a tabulation of the linear expansion of solids at ordinary temperatures, prepared mostly by the British Board of Trade, the increase in unit length for a temperature change of 1° F. is given as follows:

Slate.....	0.0000577
Sandstone.....	.00000652

In an entry 10 feet wide, therefore, if the lower layer of the roof assumes the temperature of the air, temperature changes will cause expansion as follows:

Mine-roof expansion due to temperature changes.

Kind of mine roof.	Lineal expansion due to temperature changes.	
	Diurnal change 23°.	Annual change 105°.
	<i>Inches per 10 feet.</i>	<i>Inches per 10 feet.</i>
Slate.....	0.0159	0.0727
Sandstone.....	.0180	.0822

If, therefore, this daily shrinkage and swelling of the exposed roof layers takes place as a result of temperature changes in addition to the effect caused by changes in the moisture content of the air, there need be little wonder that roof falls are particularly prevalent in the intake air courses.

In many mines in which the roof is friable, the application of the method for maintaining a uniform temperature of the intake air suggested on pages 52 to 61 would be especially desirable.

Table 7 following gives for each two-hour interval the mean monthly temperatures at the LaSalle weather-bureau station for the 16 months, February, 1912, to May, 1913.

Table 8 gives for each two-hour interval the mean monthly relative humidity at the same station during the same period.

TEMPERATURE AND RELATIVE HUMIDITY OF THE RETURN MINE AIR
DURING THE TESTS.

The temperature and relative humidity of the upcast at any mine should be approximately constant throughout the year. In the return air at the Sherrard mine, during 52 weeks, the maximum fluctuation in temperature was $1\frac{3}{4}^{\circ}$ and in relative humidity 6 per cent. This draws attention to the fact that (except in new mines) the efficiency of the main entry stoppings may be measured in terms of the seasonal changes in the temperature of the upcast.

Table 9 shows the temperature and relative humidity of the return air at three long-wall and five room-and-pillar mines in which three observations were made daily during a period of a year.

Table 10 has been compiled from the data in Tables 7, 8, and 9, in order to show the amount of moisture extracted from the average long-wall and room-and-pillar mine by the ventilating currents, when the quantity of air per minute is 100,000 cubic feet. For any other volume of ventilation, the figures in Table 10 will vary directly.

TABLE 7.—*Temperature of the outside air at the LaSalle weather-bureau station, by months, from February, 1912, to May, 1913.*

Month.	2 a. m.	4 a. m.	6 a. m.	8 a. m.	10 a. m.	Noon.	2 p. m.	4 p. m.	6 p. m.	8 p. m.	10 p. m.	Night.	Aver- age.
1912.													
February.....	18.9	17.7	16.8	16.9	19.1	22.6	24.5	24.8	22.9	21.3	20.5	19.2	20.4
March.....	24.1	23.2	22.7	23.9	28.2	31.3	33.4	33.6	31.8	29.6	28.0	26.2	28.0
April.....	45.1	43.7	43.3	47.3	52.7	56.3	58.5	58.3	56.3	51.6	48.5	47.0	50.7
May.....	57.5	55.7	56.0	61.7	66.2	69.0	72.5	72.3	70.3	65.7	62.4	60.1	64.1
June.....	59.9	58.2	59.2	66.4	72.4	76.0	77.9	77.2	74.0	68.9	65.1	62.3	68.1
July.....	67.6	65.7	66.3	72.0	77.9	81.3	83.6	83.2	80.9	75.4	71.5	69.3	74.6
August.....	64.1	63.1	63.0	68.5	74.3	77.1	78.6	78.7	76.3	71.4	68.6	66.1	70.8
September.....	60.6	59.2	58.3	63.7	70.6	73.6	74.4	73.4	69.6	65.5	62.8	60.6	66.0
October.....	46.9	45.9	45.0	49.1	57.6	62.0	64.0	62.9	57.6	53.9	50.8	48.7	53.7
November.....	38.4	37.2	35.9	36.7	42.4	46.1	48.5	48.1	44.8	42.3	41.1	39.8	41.8
December.....	31.2	30.1	28.8	28.4	31.4	35.1	37.3	36.9	34.6	33.5	32.4	31.2	32.6
1913.													
January.....	25.7	25.2	24.9	24.7	27.4	30.4	31.7	31.3	29.6	27.8	26.5	25.5	27.6
February.....	20.8	19.4	18.4	18.6	22.9	26.8	29.1	29.2	26.7	24.6	23.3	22.4	23.5
March.....	31.0	30.2	29.1	29.5	33.4	36.2	38.5	38.8	37.2	35.4	34.6	33.6	34.0
April.....	44.7	42.9	42.2	46.7	53.1	56.7	59.2	59.9	57.9	53.0	49.2	46.9	51.0
May.....	54.3	53.0	53.2	58.8	63.4	66.0	68.0	68.3	65.4	60.6	57.9	56.3	60.4
Averages for 16 months..	43.2	41.9	41.4	44.6	49.6	52.9	55.0	54.8	52.2	48.8	46.5	44.7	48.0
Number of de- grees below high tem- perature...	11.8	13.1	13.5	10.4	5.4	2.1	High.	.2	2.8	6.2	8.5	10.3	7.0

TABLE 8.—*Relative humidity of the outside air at the LaSalle weather-bureau station, by months, from February, 1912, to May, 1913.*

Month.	2 a. m.	4 a. m.	6 a. m.	8 a. m.	10 a. m.	Noon.	2 p. m.	4 p. m.	6 p. m.	8 p. m.	10 p. m.	Night.	Aver- age.
1912.													
February.....	83.4	84.3	86.0	84.1	78.8	71.7	68.0	69.0	74.9	79.3	80.1	82.5	78.5
March.....	84.0	85.0	85.7	83.4	74.3	68.9	65.9	66.3	72.2	78.5	81.3	83.1	77.4
April.....	76.6	79.5	80.7	74.4	63.6	57.6	54.2	54.2	56.7	65.8	71.8	74.3	67.5
May.....	81.4	84.0	84.1	72.7	64.0	58.0	52.2	51.6	56.4	64.4	74.1	77.8	68.4
June.....	81.0	84.5	82.0	68.6	55.4	48.1	44.2	45.8	51.6	60.2	70.2	76.0	64.0
July.....	85.6	87.9	87.3	77.3	64.6	57.6	53.2	52.1	56.5	66.7	77.9	83.0	70.8
August.....	86.1	86.7	87.0	78.9	65.5	58.8	56.6	56.0	61.2	72.4	79.9	84.1	74.4
September.....	85.6	87.2	87.9	78.5	63.1	54.7	53.3	53.7	61.6	73.2	79.8	83.9	71.9
October.....	83.3	85.2	85.5	81.6	66.5	56.2	51.7	53.5	63.1	72.5	77.8	80.6	71.5
November.....	75.1	77.2	79.2	78.7	69.1	60.6	55.7	56.1	63.2	68.2	71.0	73.1	68.9
December.....	74.5	76.4	78.2	78.2	72.6	66.9	63.1	64.3	68.4	70.0	71.7	74.1	71.5
1913.													
January.....	83.7	84.4	84.6	85.3	80.7	74.7	73.0	73.9	77.5	80.8	82.5	83.4	80.4
February.....	80.2	80.5	81.0	80.9	73.2	67.9	65.8	67.1	73.0	77.5	80.2	80.7	75.7
March.....	80.8	80.1	81.8	80.9	74.4	70.2	67.4	68.7	71.5	75.9	76.2	77.6	75.5
April.....	75.0	77.6	78.4	71.6	58.4	50.4	45.6	44.3	48.7	56.7	65.7	70.7	61.9
May.....	78.9	80.6	80.0	68.5	61.1	58.0	56.5	54.0	57.5	67.8	73.8	76.5	67.8
Average.....	81.0	82.6	83.1	77.7	67.8	61.3	57.9	58.2	63.4	70.6	75.9	78.8	71.6

TABLE 9.—*Temperature and relative humidity of the return mine air at various mines during period of tests.*

Name of mine.	System of mining.	Number of weeks of daily readings.	Data on return air.		
			Tempera- ture.	Relative humidity.	Water per 100,000 cubic feet of air.
			° F.	Per cent.	Gallons.
Oglesby.....	Long-wall.....	38	74.08	96.65	.....
LaSalle.....	do.....	52	76.62	92.02	.....
Assumption.....	do.....	52	74.32	93.36	.....
Average for long-wall mines.....			75.01	94.01	15.098
Murphysboro.....	Room-and-pillar.....	54	58.56	99.97	.....
Sherrard.....	do.....	52	68.07	95.10	.....
Harrisburg.....	do.....	46	60.66	97.15	.....
Glen Carbon.....	do.....	51	68.01	94.81	.....
Collinsville.....	do.....	52	63.93	94.19	.....
Average for room-and-pillar mines.....			63.85	96.24	10.778

TABLE 10.—*Amount of moisture extracted from average long-wall and room-and-pillar mine by ventilating currents during the tests.*

Month.	Data on the outside atmosphere, LaSalle weather-bureau station.			Water extracted by ventilating currents.					
				Average long-wall mine. ^a			Average room-and-pillar mine. ^b		
	Temperature.	Relative humidity.	Water per 100,000 cubic feet of air.	Per 100,000 cubic feet of air.	Per day at 100,000 cubic feet of air per minute.	Per month at same daily rate.	Per 100,000 cubic feet of air.	Per day at 100,000 cubic feet of air per minute.	Per month at same daily rate.
1912.	° F.	Per cent.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
February...	20.4	78.5	1.691	13.407	19,306	540,568	9.082	13,078	366,184
March.....	28.0	77.4	2.350	12.748	18,357	569,067	8.423	12,129	375,999
April.....	50.7	67.5	4.829	10.269	14,787	443,610	5.944	8,559	256,770
May.....	64.1	68.4	7.720	7.378	10,624	329,344	3.053	4,396	136,276
June.....	68.1	64.0	8.234	6.864	9,881	296,520	2.539	3,656	109,680
July.....	74.6	70.8	11.225	3.873	5,577	172,887	c. 452	c 651	c 20,181
August.....	70.8	74.4	10.448	4.650	6,696	207,576	c. 325	c 468	c 14,508
September.	66.0	71.9	8.639	6.459	9,301	279,030	2.134	3,073	92,190
October.....	53.7	71.5	5.717	9.381	13,509	418,779	5.056	7,281	225,711
November..	41.8	68.9	3.589	11.509	16,573	497,190	7.184	10,345	310,350
December..	32.6	71.5	2.646	12.452	17,931	555,861	8.127	11,703	362,793
1913.									
January...	27.6	80.4	2.398	12.700	18,288	566,928	8.375	12,060	373,860
February...	23.5	75.7	1.881	13.217	19,032	532,896	8.892	12,804	358,512
March.....	34.0	75.5	2.946	12.152	17,499	542,469	7.827	11,271	349,401
April.....	51.0	61.9	4.474	10.624	15,299	458,970	6.299	9,071	272,130
May.....	60.4	67.8	6.776	8.322	11,984	371,504	3.997	5,756	178,436

^a 4,877,360 gallons per annum.^b 2,604,140 gallons per annum.^c Deposited in the mine.

EFFECT OF HUMIDITY CHANGES ON RIB-DUST SAMPLES.

In a preliminary report of the cooperative investigations ^a the following statement was made on the collection of rib-dust samples:

Rib-dust samples have been taken at three points in each mine visited—namely, on the main haulage road, on the subsidiary haulage roads, and inside the last cross-cut near the face of an entry or a room. These samples were taken according to the following uniform method:

A chalk line was drawn from the mine roof to the floor. On one side of this line an area of rib was cleaned with a 1-inch varnish brush from the top to the bottom of the coal seam. This area was made of sufficient width for the dust to fill a 40-gram glass bottle. The material was collected on a sheet of celluloid or a piece of clean paper and transferred to the bottle, which was then sealed with a rubber cork. The height and width of the area of rib brushed was measured. Note was also made of the temperature, the relative humidity, and the distance that the air had traveled from the intake to the point of sampling.

In Table 11 following, figures are given showing the effect of the humidity and temperature changes on the rib dusts collected in 100 mines during the year 1912.

HUMIDITY CHANGES BETWEEN INTAKE AND UNDERGROUND STATIONS.

Records of humidity changes between intake and underground stations are presented in Table 11 following:

^a Preliminary report on organization and method of investigations: Illinois Coal-Mining Investigations, Cooperative Agreement. 1913, p. 44.

TABLE 11.—Humidity changes between the intake and underground stations.

No. of mine.	Place of sampling. ^a	Depth of shaft.	Air-drying loss of face sample.		Intake.		Relative humidity.	Temperature.	Relative humidity.	Water per 100,000 cubic feet of air (gals.).	Vapor pressure.	Distance.	In vapor pressure.	Amount of water per 100,000 cubic feet of air.	Heat given by (+) or loss of the ribs as compared with that of the face sample.
			Per cent.	Per cent.	Temperature.	Relative humidity.									
5	a	135	9.92	18.85	44	93	60	89	8.760	0.460	2,000	+0.193	3.516	+57.888	
6	b	100	12.66		84	68	66	95	11.415	.606	1,800	-185	-3.022	-52.225	
7	a	200	9.56	17.14	52	63	65	79	14.380	.781	300	-010	-057	-9.105	
8	b			5.73				85	9.883	.524	2,200	+280	+5.166	+62.657	
9	c			3.02	45	58	56	90	8.883	.345	2,500	+280	+5.166	+62.657	
14	a	135	12.61	17.64	66	45	57	97	6.616	.536	1,400	+172	+4.452	+46.452	
15	a	160	4.37	15.89	64	85	64	95	10.124	.536	1,200	+249	+4.717	+36.292	
21	a		6.87	12.55				90	10.686	.565	6,000	+059	+1.125	+8.150	
21	b	1,004		6.42	86	51	74	70	10.403	.554	500	+048	+0.902	+8.308	
25	a		10.75	21.64	76	83	62	89	10.889	.587	750	-046	-019	-25.301	
25	c	185		2.96				95	14.192	.769		+136	+2.684	+886	
26	a	196	10.83	2.96	88	61	67	85	9.368	.494	4,200	-250	-4.384	-55.834	
26	b		12.08	28.43				90	11.795	.628	9,000	-116	-1.957	-29.427	
27	a	170	10.17	19.65	84	47	69	83	10.124	.536	1,000	-270	-4.494	-72.600	
27	b		23.01	23.01				87	10.463	.554	10,000	-270	-4.494	-72.600	
27	c		11.06	23.01				90	10.996	.527	1,700	-219	-3.622	-57.043	
29	a	185	11.50	8.68	78	64	70	95	9.950	.577	1,500	-029	-016	-37.224	
29	b		11.50	23.01				90	10.124	.536	1,900	-020	-016	-37.224	
29	c		11.50	23.01				95	10.538	.564	3,500	+040	+1.090	-26.949	
31	a	60	11.86	9.87	70	64	69	85	11.230	.564	250	-048	-075	-19.261	
31	b	60	10.79	8.72	93	51	63	84	10.202	.544	1,000	-068	-1.090	-23.337	
32	a	67	12.35	9.03	76	67	66	90	10.553	.562	3,800	+094	+1.693	-86.496	
32	b		9.03	12.35				87	9.139	.483	3,800	-305	-5.039	-86.496	
33	a	285	10.50	21.72	77	67	66	80	11.174	.595	4,000	-193	-3.004	-65.489	
33	b		6.69	21.72				87	14.415	.780	8,000	-008	-027	-28.487	
36	a	238	11.83	22.45	87	74	66	90	9.612	.510	4,000	-110	-1.844	-32.271	
36	b	235	6.27	8.36	70	77	67	90	10.124	.536	4,000	-084	-1.332	-42.453	
37	a		7.30	10.37	79	68	68	90	10.814	.574	12,000	-374	-6.394	-79.297	
37	b		11.11	10.37				85	10.553	.562	3,800	-002	-015	-5.266	
38	a	245	6.98	19.49	74	82	67	95	11.542	.616	5,000	+052	+1.004	+3.415	
38	b		6.98	14.79				92	11.054	.587	5,500	-097	-1.518	-34.425	
38	c		11.11	14.79				92	11.795	.628	3,400	-056	-077	-27.583	
38	a	204	6.98	14.79	74	82	64	92	10.349	.547	3,000	-140	-2.407	-34.731	
38	b		11.71	3.95				90	10.524	.558	3,500	-129	-2.232	-32.564	
38	c		3.95	11.71				92	11.542	.616	8,000	-071	-1.214	-19.018	

40	a	270	10.65	22.49	79	59	66	92	11.054	587	5,400	+	.003	+	.315	-	21.184	+11.84
	b			13.38			67	85	10.727	571	5,600	+	.003	+	.578	-	20.942	+2.73
	c			7.49			70	89	12.317	639	1,500	+	.075	+	1.578	-	5.539	+3.16
41	a			6.24			69	90	11.923	636	1,800	+	.078	+	1.274	-	16.005	+1.09
42	a			7.14			70	100	13.686	732	1,200	+	.168	+	2.603	-	96.321	+11.17
43	a			4.01			66	100	12.015	638	3,000	+	.168	+	2.603	-	96.321	+12.34
44	a			15.35			66	100	12.015	638	3,000	+	.168	+	2.603	-	96.321	+12.34
	b			4.31			65	95	11.044	585	2,000	+	.376	+	6.466	-	78.015	+2.81
45	a			1.70			65	95	11.044	585	2,000	+	.376	+	6.466	-	78.015	+2.81
	b			8.81			65	95	11.044	585	2,000	+	.376	+	6.466	-	78.015	+2.81
	c			11.20			67	90	11.174	595	4,500	+	.366	+	6.336	-	73.670	+6.89
46	a			11.02			68	95	12.183	650	4,000	+	.087	+	1.808	-	7.965	+9.68
	b			2.39			68	95	12.183	650	4,000	+	.087	+	1.808	-	7.965	+9.68
	c			12.81			67	95	11.795	659	10,000	+	.065	+	1.420	-	11.942	+1.95
49	a			10.04			70	90	12.317	659	10,000	+	.066	+	.457	-	27.337	+6.99
	b			7.48			70	90	12.317	659	10,000	+	.066	+	.457	-	27.337	+6.99
	c			8.40			70	90	12.317	659	10,000	+	.066	+	.457	-	27.337	+6.99
50	a			6.42			69	95	12.585	672	3,000	+	.006	+	.457	-	20.062	+2.70
	b			12.22			60	90	11.923	636	2,000	+	.117	+	2.382	-	20.062	+2.70
	c			5.72			60	90	13.001	695	2,500	+	.058	+	.966	-	15.420	+8.50
51	a			16.00			63	84	9.139	483	2,000	+	.110	+	1.910	-	15.420	+8.50
	b			13.59			61	81	8.245	434	1,700	+	.061	+	1.016	-	26.769	+10.11
	c			11.78			62	89	9.368	494	3,500	+	.121	+	2.139	-	36.740	+7.70
52	a			8.17			70	81	11.086	563	8,000	+	.435	+	7.925	-	4.08	+5.89
	b			3.60			60	78	7.808	411	4,000	+	.253	+	4.647	-	88.833	+4.0
	c			4.76			60	78	7.677	403	16,000	+	.245	+	4.516	-	86.863	+6.7
53	a			14.19			64	90	10.124	536	9,000	+	.137	+	2.426	-	31.406	+6.99
	b			6.27			63	89	9.683	512	10,000	+	.161	+	2.867	-	36.417	+9.93
	c			5.16			63	90	9.792	518	8,000	+	.155	+	2.758	-	35.650	+2.04
54	a			7.63			65	90	10.463	554	4,000	+	.194	+	3.522	-	47.038	+4.45
	b			17.72			62	92	10.875	577	3,000	+	.217	+	3.924	-	47.038	+4.45
	c			11.18			61	90	9.568	504	3,900	+	.144	+	2.697	-	33.846	+10.24
55	a			19.04			64	87	8.950	527	6,600	+	.347	+	6.332	-	33.846	+10.24
	b			13.13			04	92	10.349	547	9,500	+	.387	+	6.731	-	116.067	+12.96
	c			12.32			05	90	10.463	554	3,960	+	.374	+	6.845	-	116.067	+12.96
56	a			12.10			06	85	10.814	574	1,600	+	.219	+	4.231	-	119.055	+7.05
	b			7.16			04	85	9.361	506	1,400	+	.151	+	2.078	-	12.905	+8.96
	c			14.19			04	90	10.124	536	6,000	+	.181	+	3.541	-	4.711	+4.02
57	a			14.19			04	90	10.124	536	6,000	+	.096	+	1.628	-	27.363	+11.05
	b			9.76			05	90	10.463	554	2,000	+	.078	+	1.289	-	23.536	+10.75
	c			23.48			04	90	10.124	536	2,000	+	.096	+	1.628	-	23.536	+10.75
69	a			27.19			07	85	10.814	574	9,000	+	.224	+	3.656	-	52.427	+15.38
	b			9.24			07	85	10.553	562	9,000	+	.224	+	3.656	-	52.427	+15.38
	c			17.43			06	88	12.045	644	2,000	+	.142	+	2.335	-	36.636	+19.09
75	a			8.11			06	95	11.605	617	4,000	+	.210	+	3.587	-	55.817	+1.14
	b			12.31			69	90	11.923	636	4,000	+	.191	+	3.269	-	55.817	+1.14
	c			21.91			69	90	11.851	633	1,200	+	.194	+	3.341	-	48.879	+8.9
78	a			18.53			66	100	12.015	638	5,000	+	.139	+	2.255	-	48.879	+8.9
	b			9.24			71	95	13.425	719	5,000	+	.058	+	.845	-	42.230	+3.31
	c											+	.058	+	.845	-	42.230	+3.31

a The place of sampling is denoted by letters as follows: a—a dust taken inside the last crosscut of an entry or room near the "working face;" b—a dust taken along the subsidiary haulage roads; c—a dust collected on the main haulage roads.

b Road-dust samples.

TABLE 11.—Humidity changes between the intake and underground stations—(Continued).

No. of mine.	Place of sampling.	Depth of shaft.	Air-drying loss of rib dust sample.		Intake.		Mine station.				Changes between intake and mine station.				
			Per cent.	Per cent.	Temperature.	Relative humidity.	Temperature.	Relative humidity.	Water per 100 cubic feet of air (gals.).	Vapor pressure.	Distance.	In vapor pressure.	Amount of water per 100,000 cubic feet of air.	Heat given by (+) or lost (-) the mine ribs as compared with that of the face sample.	
79	(a).....	127	16.40	7.41	82	65	63	100	10.880	.575	6,000	-.144	-2.101	-48,451	+ 8.99
	(b).....		16.40				63	100	10.880	.575	6,000	-.144	-2.101	-48,451	+ 9.19
	(c).....		12.10				64	90	10.124	.536	7,000	-.183	-2.857	-51,500	+ 4.69
80	(a).....	145	6.52	5.20	82	80	62½	94	10.061	.531	12,500	-.342	-5.916	-84,503	+ 1.32
	(b).....		8.06				65	87	10.284	.545	4,000	-.328	-5.693	-67,613	+ 3.46
	(c).....	200	25.49	4.80	84	66	62½	94	9.894	.522	3,500	-.246	-4.118	-67,437	+ 20.69
81	(a).....		15.20				63½	97	10.636	.567	3,000	-.201	-3.386	-59,537	+ 10.40
	(b).....		5.05				65	90	10.463	.554	10,000	-.214	-3.549	-57,673	+ 25
	(c).....	192	17.48	7.27	78	79	64	100	11.249	.595	9,000	-.191	-2.689	-43,577	+ 10.21
82	(a).....		11.63				64	95	10.686	.565	7,000	-.171	-2.952	-47,424	+ 4.36
	(b).....		9.94				65	95	11.044	.585	15,000	-.384	-2.894	-42,765	+ 2.67
	(c).....	140	13.23	6.35	93	62	63	100	10.880	.575	6,000	-.171	-2.894	-42,765	+ 2.67
83	(a).....		9.68				67	95	11.795	.628	7,000	-.331	-3.441	-80,318	+ 3.83
	(b).....		12.23				67	90	11.174	.595	7,000	-.304	-6.062	-84,173	+ 2.95
	(c).....	320	5.85		93	57	69	100	13.248	.707	4,500	-.174	-2.598	-59,027	+ 5.97
84	(a).....	85	4.42		94	54	67	95	11.795	.628	3,000	-.233	-3.665	-57,343	+ 3.39
	(b).....		8.01				71	90	10.336	.546	30,000	-.180	-2.741	-88,697	+ 13.08
	(c).....	85	5.18		82½	62	62	94	9.894	.522	4,600	-.166	-2.681	-55,130	+ 11.52
89	(a).....		16.70				66	100	10.880	.575	4,600	-.113	-1.695	-46,589	+ 11.40
	(b).....		16.58				66	90	10.814	.574	9,000	-.114	-1.761	-41,285	+ 8.31
	(c).....	160	5.44		84	70	63	90	9.792	.518	1,200	-.296	-5.070	-71,792	+ 6.59
90	(a).....		13.75				62	94	9.894	.522	1,200	-.292	-4.968	-73,146	+ 17.06
	(b).....		27.83		35	100	60	89	8.761	.460	1,900	+.257	+ 6.471	+ 108,500	+ 15.78
	(c).....	217	10.77				64½	92	10.522	.557	1,900	+.354	+ 6.471	+ 108,500	+ 13.03
91	(a).....		26.55				64½	93	6.607	.341	5,000	+.138	+ 2.556	+ 51,236	+ 105.697
	(b).....		23.80				50½	94	7.389	.421	Return.	+.333	+ 5.591	+ 105,697	+ 44.264
	(c).....	240			20½	64	56	84	3.949	.199	500	+.111	+ 11.944	+ 11,151	+ 138,228
93	(a).....		13.27		20½	85	56½	92	9.139	.479	Return.	+.391	+ 7.321	+ 76,971	+ 11.97
	(b).....	186					24	87	2.269	.108	Intake.	+.391	+ 7.321	+ 76,971	+ 11.97
	(c).....	223	11.20		42	85	61½	92	9.525	.502	900	+.276	+ 5.066	+ 81,407	+ 36.82
97	(a).....		45.39				63½	88½	9.711	.513	1,500	+.140	+ 2.595	+ 41,971	+ 4.94
	(b).....		48.02				53	91	7.054	.366	1,800	+.302	+ 5.487	+ 35,322	+ 3.74
	(c).....	400	7.84		78	60	81	83	16.073	.876	2,000	+.286	+ 5.250	+ 35,322	+ 3.74
100	(a).....		4.10				79	87	15.836	.860	5,400	+.286	+ 5.250	+ 35,322	+ 3.74
	(b).....														
	(c).....														

GENERALIZATIONS.

The records presented in Table 11 warrant the following generalizations:

1. The evaporation of water proceeds rapidly when conditions are favorable. In Mine No. 97, in 900 feet the amount of water evaporated per 100,000 cubic feet of air was 5.066 gallons, or 5.63 gallons per 1,000 feet of entry. In Mine No. 31, in 100 feet the amount of water evaporated was 1.693 gallons per 100,000 cubic feet of air, or 16.93 gallons per 1,000 feet of entry. In each of these mines the movement of the air was sluggish and the change in vapor pressure was very large for the difference in distance. In general, the lower the temperature of the intake air as compared with the temperature of the return air, the greater will be the quantity of water evaporated. In Mine No. 52, where the intake temperature was 36° F. below that of the return, 7.925 gallons of water was evaporated for every 100,000 cubic feet of air. In Mine No. 93, 7.321 gallons was evaporated for a temperature difference of 38° F. In Mine No. 55, for 33° F. difference in temperature, 6.845 gallons of water was evaporated.

2. The deposition of water is rapid under favorable conditions. In Mine No. 90, in 700 feet, the amount of water deposited per 100,000 cubic feet of air was 5.07 gallons, or 7.24 gallons per 1,000 feet of entry. The higher the temperature and relative humidity of the intake air as compared with the return, the larger will be the quantity of water deposited. In Mine No. 83, 6.356 gallons of water was deposited for a temperature difference of 30° F.; in Mine No. 36, 6.394 gallons in 21° F.; and in Mine No. 45, 6.466 gallons in 20° F.

3. The temperature of the intake air is quickly changed to the temperature of the mine strata. In Mine No. 97, 900 feet from the shaft, which was 223 feet deep, the temperature was raised $19\frac{1}{2}^{\circ}$ F.; and in Mine No. 90, 700 feet from the 160-foot air shaft, the temperature was lowered 21° F. An important agent in bringing about a rapid drop in temperature is water falling in the intake shaft. At Mine No. 90, just mentioned, considerable water occurs at the shaft.

4. The dust investigations were made at irregular intervals during 1912, but the greater part of the readings (76 per cent) was taken in the summer months when the temperature of the intake air was higher than that of the return air. The influence of the relative humidity of the intake air is indicated by the fact that 42 per cent of the records show that evaporation was taking place.

5. In 92 per cent of the samples taken inside the last crosscut of an entry or room near the "working face" (location *a*) the rib dust lost more water on air drying than did the face sample of coal. In 76 per cent of the dusts taken along the subsidiary haulage roads (location *b*) more water was lost on air drying than was lost by the face sample of coal. In 78 per cent of the samples collected on the

main haulage roads (location *c*) the air-drying loss was greater than that of the face sample of coal. It is apparent that, in this series of tests, the rib dusts, especially those collected near the working faces, showed a tendency to contain more mechanically held water than did the face samples of coal. The fineness of the dusts, and the fact that most of the samples were gathered in the summer when condensation was taking place, are suggested as reasons for the high moisture content of these dusts.

6. In the majority of these tests (59 per cent) the rib dusts showed a moisture content that varied according to whether the ventilation currents had caused evaporation or deposition of moisture on entering the mine. This relation was noticed in Mines Nos. 27, 38, 41, 44, 50, 69, 78, 79, 80, 81, 82, 83, 88, 89, 90, and 100. The seeming exceptions may have been due to one or all of the causes mentioned below:

(a) The roadways were sprinkled shortly before some of the samples were taken. Samples Nos. 51, *b* and *c*, 52, *c*, and 56 *a*, *b*, and *c*, are examples. In the mines from which those samples were taken sprinkling is done every night—by cars at Mine No. 51 and by hose at Mines Nos. 52 and 56.

(b) The time of year during which the samples were collected varied. Sample No. 37, *b*, and sample No. 37, *c*, were obtained on August 10, 1912, when the temperature was temporarily below the normal for that time of year.

(c) The temperature of the ventilation air in some mines was lowered below the mine temperature owing to the evaporation of water, and was then reheated through the agency of the mine ribs, further evaporation being thus permitted. In Mine No. 39, at location *b*, 0.6 mile from the intake, the temperature was 64° F.; and at location *c*, 1.6 miles from the intake, the temperature was 68° F. and the dust contained 7.76 per cent less moisture than did the dust at location *b*.

(d) Mine water may have been present in unusually large quantities. In Mines Nos. 91 and 97 large quantities of water are found at the shafts and wherever breaks occur through to the surface. Consequently these mines even in winter are damp and the rib dusts show large amounts of mechanically held moisture.

7. The extent to which the ribs, roof, and floor of mine workings radiate and absorb heat depends on whether the temperature of the air is less or greater than that of the mine strata. In Mine No. 93 the average quantity of air delivered by the fan is 125,000 cubic feet per minute; and on February 27, 1912, when the humidity reading was made, 138,228 British thermal units was given up by the walls of the workings to each 100,000 cubic feet of the ventilation. This quantity of heat would be equivalent to that obtained by burning about 11 tons of coal per 24 hours.

The absorption of heat by the walls of the mine workings is shown to be very large in Mine No. 83, where the heat absorbed per 100,000 cubic feet of air amounted to as much as 94,957 heat units.

The main factor governing the extent of radiation or absorption of heat by the surfaces of the rooms and entries is shown in Table 11 to be the difference between the temperature of the intake air and that of the mine strata.

METHODS OF MINE HUMIDIFICATION IN ILLINOIS.

In 88 mines, carefully selected to represent the general conditions in Illinois, a study has been made of the methods adopted to humidify the coal dust, as well as of the amount, character, and occurrence of the mine water.

The quantity of water pumped from the average mine in Illinois is not excessive, the greatest quantity reported being 1,000,000 gallons per 24 hours. A few hours' pumping each day is sufficient to keep most mines free from water. In two mines visited the quantity of water was so small that no pump was installed and any excess water was loaded into tank cars and hoisted to the surface.

The character of the mine water as reported by the different mine managers was acid in 42 per cent of the mines, and alkaline in 15 per cent, and in 43 per cent was neutral, being suitable for boiler use and in many being fit for drinking.

In 55 per cent of the mines the water occurred principally at the shafts, in 20 per cent at the mine faces, and in 25 per cent at other sections, such as at points of heavy falls, breaks to the surface, and dip workings.

There was no means of artificial humidification and no attempt to control the condition of the dust in 25 per cent of the mines. In most of the mines of this group the underground workings were either naturally damp because of nearness to the surface, or the dust was so mixed with shale from roof or floor that special humidification was unnecessary. In some of the mines, however, the dust was dry, very abundant, and a source of danger.

USE OF WATER CARS.

Of the mines into which water was introduced artificially 91 per cent used water cars. The frequency of sprinkling by this means was as follows:

Frequency of sprinkling with water cars.

Interval between sprinkling.	Number of mines.	Interval between sprinkling.	Number of mines.
	<i>Per cent.</i>		<i>Per cent.</i>
6 months.....	1.7	1 week.....	35.0
3 months.....	1.7	3 days.....	3.3
1 month.....	5.0	2 days.....	6.7
Irregular.....	23.3	1 day.....	10.0
2 weeks.....	13.3		

The type of water cars varied. The usual form was that of an old mine car calked and covered and containing two or three holes through which the water flowed to the roadways. The most advanced type, found in a few mines, was that of a steel tank mounted on wheels and equipped with sprinkling apparatus, being similar to a city street sprinkler. This type contained apparatus that compressed the air to give sufficient force to the spray to wash the ribs and the roof as well as sprinkle the floor.

The capacity of the cars varied from 250 to 700 gallons. The average cost of sprinkling was \$1 per 1,000 gallons. The objections to the use of water cars for sprinkling the coal dust are as follows: In winter the water supplied does not equal the amount removed by the ventilating currents; the sprinkling is performed only on haulage roads, and not near the faces where windy and blown-out shots originate; in general only a part of one surface (the floor) of the entry is moistened, whereas the other three surfaces (the two ribs and the roof) are untouched; sprinkling dry floor dust in this manner is in general ineffective, as usually the dust is not thoroughly dampened but some of it floats on the water; "loads" or "empties" often have to be switched to permit the passing of the water car; the cost is high.

The water car is valuable in many mines in supplementing some other form of humidification, such as exhaust steam, water from fixed sprays or hose, or shale dust.

USE OF WATER HOSE.

The use of water hose has been effective in eliminating the dangers from blown-out or windy shots in 6 per cent of the mines visited.

At one mine two men with hose sprinkle every night, washing the ribs, roof, and posts on the cross entries. In this way each entry is washed every week.

At another mine there is sufficient hose to reach each working face, and the ribs, roof, face, and props of each room are washed down at least once each month.

The cost of sprinkling by hose, exclusive of the piping installation, was 60 cents per 1,000 gallons; the total cost of sprinkling per ton of coal was 0.5 cent in mines where the entries were washed each week.

HUMIDIFICATION BY STEAM.

Steam was used for humidification in 16 per cent of the mines. The common practice was to admit the exhaust from the fan engine into the intake shaft.

In one mine (No. 29) steam jets placed at various points in the air shaft effectively preheated the intake air during cold weather.

In three mines (Nos. 25, 59, and 100) the downcast air passed over radiators, one radiator containing 695 feet of 1-inch pipe, another 1,000 feet of 1½-inch pipe, and the third 3,000 feet of 1-inch pipe. In the two radiators first mentioned the steam was carried at about 80 pounds pressure and was exhausted outside; the radiator last mentioned was connected with the exhaust of the fan engine and was guaranteed to preheat 50,000 cubic feet of air per minute from 0° to 35°.

In many mines advantage was taken of the heat radiated from steam pipes by conducting the pipes through the downcast shafts, thus causing some preheating of the intake air.

The cost of using exhaust steam was practically nothing, and the cost of live steam (with coal at the mine valued at \$1 per ton) was 44 cents per 1,000 gallons of water evaporated.

The use of steam could be made more efficient if the problem at each mine were studied in the light of the information given on pages 52 to 61 of this report.

ADMIXTURE OF FOREIGN MATERIAL WITH ROAD DUST.

The admixture of shale, ashes, or other foreign material with the road dust is a method of dust control that proved effective in a number of mines. In the Longwall field the shale falls naturally and in sufficient quantities to check the propagation of a dust explosion.

USE OF ASHES AS ROAD BALLAST.

In one room-and-pillar mine (No. 62) ashes obtained from the boiler plant on the surface were applied to the haulage roads in the following manner: When an entry had been driven far enough to warrant laying of the permanent road, the ballasting was done entirely with ashes, the roadway having been cleaned of all dust and dirt. Then, as coal dust became mixed with the ashes, additional ashes were applied, 76 cubic feet of ashes covering 40 linear feet of track. In this manner 150 cubic feet of ashes was used every day. This method was supplemented by sprinkling the roads every night by water cars, about 2,000 gallons of water being applied every 24 hours. At this mine the rib dust seemed damp. Two years ago a bad gas explosion started and killed eight men; but the force died down because of the dampness of the dust and the admixture of ashes. This method of diluting the coal dust is effective.

USE OF STANDING BODIES OF WATER.

Standing bodies of water on the floor of intake air courses supply a certain amount of moisture to the air. In one mine (No. 56) a permanent body of water, with an average depth of 18 inches, covered

150 feet of the air course. This form of humidification is valuable merely as an auxiliary to some more approved method and then only provided it does not obstruct the airway.

USE OF CALCIUM CHLORIDE.

The use of calcium chloride was noted at one mine in Saline County. One and one-fourth pounds per square yard of floor, with the coal dust 1 inch thick, was reported to have kept the dust moist for six fall and winter months. The cost of the calcium chloride was \$13 per ton f. o. b. the mine. The results were claimed to have been satisfactory.

At mines where the roads were cleaned frequently it was noted that less sprinkling was required.

EXHAUST FANS COMPARED WITH PRESSURE FANS.

Most of the mines of Illinois do not generate much methane. In the comparatively few mines where this explosive gas is found, the amount generated in the ordinary mining operations is small. There is not a "safety-lamp" mine in the State. For convenience therefore most of the mines are ventilated by force fans.

Where a pressure fan is in use and the hoisting shaft is the upcast the following conditions prevail:

EFFECT OF PRESSURE FAN ON BOTTOM OF MAIN SHAFT.

1. At the bottom of the main shaft there is throughout the year an approximately uniform temperature and relative humidity. This uniformity is appreciated by the cagers because they are not subjected to the heat of summer or the cold of winter—effects of temperature that are intensified by the high velocity of the air current. The roof also is not weakened by either the seasonal or the diurnal changes in temperature and humidity, and there is therefore less likelihood of falls at places where a number of men are continuously at work, all men departing from and entering the hoisting cage together, usually at least once each shift.

EFFECT OF PRESSURE FAN ON MAIN HAULAGE ROADS.

2. The main haulage roads are on the return of the air. The temperature and relative humidity are much more uniform than in the intake airways; falls are therefore less likely to occur along the haulage roads, accidents are not so frequent, and delays in handling the coal are reduced. Furthermore the coal dust that leaks through or is spilled from the cars and ground by the wheels on the road and by the tramping of men and mules is not robbed so completely of moisture during the winter as would be the case if these

roads were on the intake of the air. Also the air that leaks through brattices and stoppings passes from the air courses into the haulage roads, and if moisture is deposited it is on the return side of the stoppings, whether the temperature of the leaking air is higher or lower than that of the return, owing to the reduction in temperature of the air of higher temperature by that of the lower temperature.

USE OF PRESSURE FAN MAKES POSSIBLE EFFICIENT HUMIDIFICATION.

3. Opportunities are offered for the cheap and efficient preheating and premoistening of the intake air with the aid of steam and water sprays, which will cause the temperature and relative humidity of the mine atmosphere to be uniform throughout the year.

SUMMARY AND SUGGESTIONS.

DETAILS GOVERNING CHOICE OF HUMIDIFICATION METHODS.

Before a suitable method can be adopted for humidifying the air at any mine, a thorough investigation embracing the features mentioned below should be made.

CHARACTER OF FACE SAMPLE.

A face sample should be taken and analyzed. If the sum of the ash and the moisture contents is more than 50 per cent, the possibility of an extended dust explosion is materially reduced but not obviated.

The explosibility indicates the relative danger of a given coal dust and gives an index of the need of changing the character of the mine air. The relative explosibility of 100 Illinois coals is being studied by the representatives of the bureau engaged in the cooperative work at Urbana, and a report is being prepared. A brief statement of the method of this investigation is given in the preliminary report.^a

CHARACTER OF RIB AND ROAD DUSTS.

The rib dust is the fine dust that lodges lightly on the roof and ribs and is easily thrown into suspension by runaway trips, blown-out shots, and explosions. Road dust is the dust that accumulates along roadways and is caused by leaky cars, weak roofs, and soft bottoms. A proximate analysis and an explosibility test should be made for these dusts as outlined for the face sample.

Another important consideration is the quantity and fineness of these dusts. Under the cooperative mining investigation three samples of rib dust and two samples of road dust were collected from each of 100 mines in Illinois; and the investigation has shown that

^a Preliminary report on organization and methods: Illinois Coal-Mining Investigations, Cooperative Agreement, 1913, pp. 43-45, 67-71.

in every case the quantity of rib dust finer than 20-mesh is sufficiently large to propagate an explosion.

The Danville field is an example of a district where the mines contain large quantities of fine rib dust and yet where there has never been an explosion. The weak shale roof spalls off, falls on the roadways, and mixes with the coal dust; the comparatively shallow mines contain a large amount of water; and the result is that, although the face sample would indicate a coal with an inflammable dust, there have been no explosions because the aggregate quantity of the moisture and ash in the rib and road dusts is very high.

PRESENCE AND SITUATION OF MINE WATER.

The presence and situation of the mine water and its effect in increasing the humidity of the air should be carefully ascertained by means of psychrometric readings. The places where the water enters the mine and the quantity per 24 hours are important considerations. If the water occurs at the face and is loaded out with the coal, it will assist in sprinkling the roadways as the cars go to the shaft; it will also prevent a large amount of dust from being thrown into suspension during the loading of the coal, and will thus lessen the amount of float dust and of rib and road dusts.

If the water runs in ditches down slope haulageways, it will assist in preventing the formation of dry dust along these roads. If the water occurs along the intake air courses, it will assist in supplying the moisture needed by the intake air during the greater part of the year and will lessen the amount of water extracted from the dust at the working faces. If the water occurs in the shafts, it will be of benefit in the downcast air shaft only.

CLIMATIC CONDITIONS.

The temperature and absolute humidity of the intake air vary with the climatic conditions. In Illinois the climatic conditions, although comparatively uniform throughout the State, differ greatly from those in the dry climate of Colorado or Oklahoma. In general, the less the average amount of moisture in the outside air and the colder the average temperature, the greater will be the need for humidification.

SEA-LEVEL ELEVATION OF THE MINE WORKINGS.

In any particular coal field, the deeper the mine the higher will be the temperature of the return air; but in Illinois the deepest mine at present is only 1,004 feet, and the deepest coals in the south central part of the Illinois basin are not over 1,500 feet. At these depths there is no serious difficulty in adequately humidifying coal mines.

QUANTITY OF AIR IN CIRCULATION.

As the quantity of water in a unit volume of return air at any mine is nearly constant during the entire year, the amount of moisture extracted from the dust will vary directly with the quantity of air in circulation. Therefore the quantities of heat and moisture required for humidifying the intake air depend on the volume of the ventilating current.

In many mines, 60 to 80 per cent of the air delivered by the fan is lost through leaky stoppings and doors; but this air absorbs heat and moisture before leaving the mine. If, therefore, by the construction of tight masonry or concrete stoppings along main haulageways and by the substitution of overcasts for doors it is possible to reduce the amount of air required to be delivered by the fan and at the same time to maintain sufficient air at the working faces, less water will be extracted from the mine by the return air current and less heat and moisture will be required to humidify the intake air.

UPCAST OR DOWNCAST AT HOISTING SHAFT.

If a force fan is used, it is usually possible and convenient to apply any efficient method of humidification, such as the use of exhaust steam or water sprays directly to the intake air without interfering with the haulage, travel of men, etc. Furthermore, the humidification of the air may be started in the air shaft as soon as the air leaves the fan.

With an exhaust fan the problem becomes more difficult. Unless the top of the hoisting shaft is inclosed and the air preheated before entering the shaft, humidification must be delayed until the air has begun to travel through the mine. Sprays must then be placed on main haulage and traveling ways and will cause inconvenience. But gaseous mines require that the haulage be on the intake roads, and in those mines the fan must exhaust.

When a mine is opened in a district where the coal dust is known to be explosible, special arrangements should be made for premoistening and preheating or precooling the intake air. A separate air course would be advisable in order that the humidification of the intake air may be perfected without causing inconvenience; for example, if the intake were the traveling way for the men, exhaust steam would be objectionable because of the fog that would be caused.

PRESENCE OF METHANE OR FIRE DAMP.

Methane intensifies the dangers of coal-dust explosions. The ignition of a small body of the gas may start a dust explosion; and in the case of an overcharged shot, methane may render explosive the gases from the shot. If methane is present, special care should be taken to make the coal dust inert.

CHARACTER OF THE ROOF.

The more tender the roof, the greater the need for maintaining uniform temperature in the intake. Both the seasonal and diurnal changes in temperature cause alternate expansion and contraction of the roof, which in turn causes heavy falls.

As a rule, also, the weaker the roof, the more uniform should be the relative humidity; for alternate wetting and drying of a roof causes it to disintegrate rapidly.

TENDENCY FOR ICE TO FORM IN ESCAPE WAYS.

During the months of January and February, 1912, many mines were idle several days because of inability to prevent ice forming in the intake shafts. Reversal of the ventilation may not suffice to clear a frozen shaft of ice, because ice forms rapidly as water seeps into the shaft, whereas the ice melts slowly because only the surface of the frozen mass is exposed to the warm air. The practice of reversing the fan, therefore, may cause both shafts to become blocked with ice in severe weather. Furthermore, reversal of the air in a mine producing any fire damp is dangerous.

As a blocked escape way may cause many fatalities, it is imperative that the formation of ice in a shaft should be prevented. As a rule it is cheaper, and it is always safer, to preheat the air than to chop the ice.

METHOD OF HUMIDIFYING MINE AIR WITH STEAM.

After a series of observations, such as outlined, has shown that in a certain mining district humidification is required to make the mines safe from dust explosions, information is often desired on the use of steam for humidifying the intake air.

In humidifying by steam the exhaust from the fan engine is usually turned into the downcast shaft. This practice is inefficient because it will correct conditions at any mine for only one particular temperature of the outside air. For example, if the ventilating current comprises 50,000 cubic feet of air per minute, with a return temperature of 60° F., and if the horsepower of the fan engine is 33.4, the quantity of heat in the exhaust from the fan will correct the intake temperature only when the outside air is 43°. If that air becomes either colder or warmer, too little or too much heat will be admitted by the steam. In a mine at Gillespie, on a cold night in January, 1912, a small amount of exhaust steam that had been turned into the intake was transformed into snow, and completely blocked the foot of the air shaft. In a mine at West Frankfort, when too much steam was suddenly admitted, expansion of the roof due to the high temperature caused heavy falls of rock. In some mines the amount of steam admitted is gaged by the position of the fog line.

In order that the method of using steam may be efficient, it should be based on the quantity of steam necessary to give the heat units required to raise the temperature of the intake air to that of the return, and also on the quantity of water necessary to saturate the volume of the intake air at the higher temperature; in order that the method may be practical, the admission of the steam should be under a convenient control.

CALCULATIONS AND TABLES.

The tables and calculations following are based on the use of live steam; but exhaust steam, which carries about 85 per cent of the heat value of live steam, may be used with success, provided the conditions at any given mine are carefully considered.

FORMULAS AND THEIR DERIVATION.

Formula *a* will assist in finding the quantity of water in the form of steam necessary to raise the temperature of the intake air to that of the return air. If the temperature of the return air is 60° F. and if live steam is used, the required quantity of steam, as shown by formula *c*, is a temperature of the function of the weight of the intake air and of the difference between the intake and that of the return air.

In developing the three formulas following, values have been assigned as follows:

t' = temperature of the outside air, in degrees Fahrenheit.

t = temperature of the return air, in degrees Fahrenheit.

$T = \frac{4t + 3t'}{7}$, which will approximate the average temperature at which water will evaporate in a coal mine.

W = weight in pounds of 100,000 cubic feet of air at the temperature t' .

h = specific heat of air for constant pressure, or 0.2375 British thermal units.

H = total heat above 32° F. in 1 pound of steam at 3.5 pounds pressure, or 1,150 British thermal units.

L = latent heat of evaporation, in British thermal units, per gallon of water, or 9,116 - 58.5 ($T - 32$).

P = pounds of water in the form of steam required to furnish the heat units to raise the temperature of the weight of air W from the temperature t' to the temperature t , and is equal to $\frac{\text{weight of air} \times \text{specific heat of air} \times \text{pressure difference}}{\text{latent heat in 1 pound of steam above } t \text{ degrees}}$.

G = gallons of water corresponding to P or $\frac{P}{8.35}$.

D = gallons of water in 100,000 cubic feet of return air.

D' = gallons of water in 100,000 cubic feet of outside air.

The latent heat in 1 pound of steam at t degrees is equal to H , the total heat above 32° F., minus the sensible heat between 32 degrees and t degrees.

By using the values noted above, the following formulas may be derived:

$$(a) \quad G = \frac{P}{8.35} = \frac{Wh(t - t') + L(D - D')}{8.35[H - (t - 32)]}$$

which is derived as follows:

Number of B. t. u. required to heat the weight of air (W)= $Wh(t-t')$.

Number of B. t. u. required to furnish the latent heat for the evaporation of the additional water in the heated air as compared with the water in the unheated= $L(D-D')$.

Number of B. t. u. per pound of steam at the temperature (t)= $H-(t-32)$.

$$\text{Therefore } P = \frac{Wh(t-t') + L(D-D')}{H-(t-32)}$$

$$\text{or } G = \frac{P}{8.35} = \frac{Wh(t-t') + L(D-D')}{8.35[H-(t-32)]}$$

If $L=0$, which will be true when live steam is used, on the assumption that the heat given up by condensation will equal that absorbed by evaporation

$$(b) \quad G = \frac{P}{8.35} = \frac{0.028,443,1W(t-t')}{1150-(t-32)}$$

If $t=60^{\circ}\text{ F}$

$$(c) \quad G = 0.000,025,34W(t-t').$$

QUANTITY OF WATER AS STEAM NECESSARY TO RAISE TEMPERATURE OF OUTSIDE AIR TO 60° F .

With the aid of the above formula, Table 12 has been prepared to show the quantities of live steam necessary to raise the temperature of 100,000 cubic feet of air from various temperatures of the outside atmosphere to 60° F . From the figures for the boiler horsepower and the tonnage of coal required to furnish the necessary steam the cost data can be prepared for comparison with other methods of humidification.

TABLE 12. —Quantities of live steam required to raise a volume of 100,000 cubic feet of air from various outside temperatures to 60° F .

Temperature of the intake air.	Weight of 100,000 cubic feet of air.	Heat required to raise 100,000 cubic feet of intake air to 60° F .	Water required in the form of steam at 3.5-pound pressure to raise temperature of intake air.	Boiler horsepower.	Coal required per 24 hours.
$^{\circ}\text{ F}$.	Pounds.	B. t. u.	Gallons.		Tons.
0	8,635.4	123,054	13.13	219	7.8
10	8,459.4	100,455	10.72	179	6.4
20	8,275.5	78,617	8.39	140	5.0
30	8,106.3	57,757	6.16	103	3.7
40	7,943.9	37,734	4.02	67	2.4
50	7,787.9	18,496	1.97	33	1.2
60	7,637.9				

Figure 4 shows the quantity of steam, in gallons per minute, required to raise any given volume of ventilating current from different temperatures of the outside atmosphere to 60° F . The boiler horsepower and coal required to furnish the steam would be as follows:

Boiler horsepower and coal required to raise temperature of intake air.

Quantity of water, as steam, necessary to raise temperature of intake air to 60° F.	Boiler horse-power required to evaporate water.	Coal burned per 24 hours.	Quantity of water, as steam, necessary to raise temperature of intake air to 60° F.	Boiler horse-power required to evaporate water.	Coal burned per 24 hours.
<i>Gallons per minute.</i>	<i>Continuous horsepower.</i>	<i>Tons.</i>	<i>Gallons per minute.</i>	<i>Continuous horsepower.</i>	<i>Tons.</i>
1	16.7	0.60	11	183.7	6.56
2	33.4	1.19	12	200.4	7.15
3	50.1	1.79	13	217.1	7.75
4	66.8	2.39	14	233.8	8.35
5	83.5	2.98	15	250.5	8.94
6	100.2	3.58	16	267.2	9.54
7	116.9	4.17	17	283.9	10.13
8	133.6	4.77	18	300.6	10.73
9	150.3	5.37	19	317.3	11.33
10	167.0	5.96			

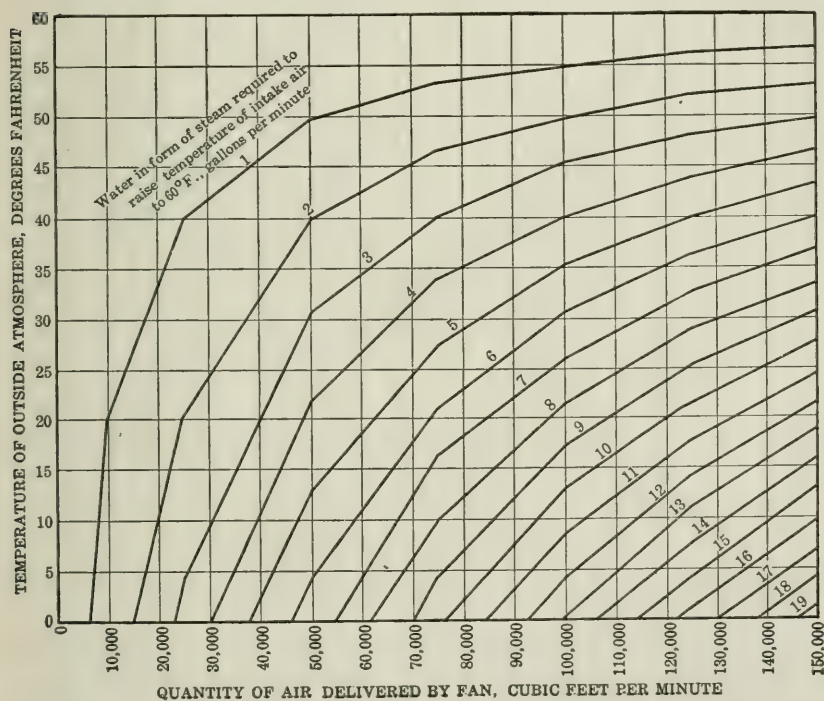


FIGURE 4.—Curves showing quantity of live steam necessary to raise temperature of 100,000 cubic feet of intake air from various temperatures to a temperature of 60° F.

QUANTITY OF WATER REQUIRED TO SATURATE IN RAISING TEMPERATURE.

The quantity of moisture in any volume of the outside atmosphere depends on the temperature and relative humidity of the air. A volume of 100,000 cubic feet at a temperature of 60° F. requires for saturation 9.843 gallons, or approximately 10 gallons, of water.

Figure 5 shows, for different temperatures and relative humidities of the outside air, the quantity of water that must be added per 100,000 cubic feet for saturation if the temperature of the air is raised to 60° F.

QUANTITY OF MOISTURE IN OUTSIDE AIR ACCORDING TO TEMPERATURE AND RELATIVE HUMIDITY.

A volume of intake air, when heated by steam to the temperature of the return, will contain a quantity of moisture equal to that in a

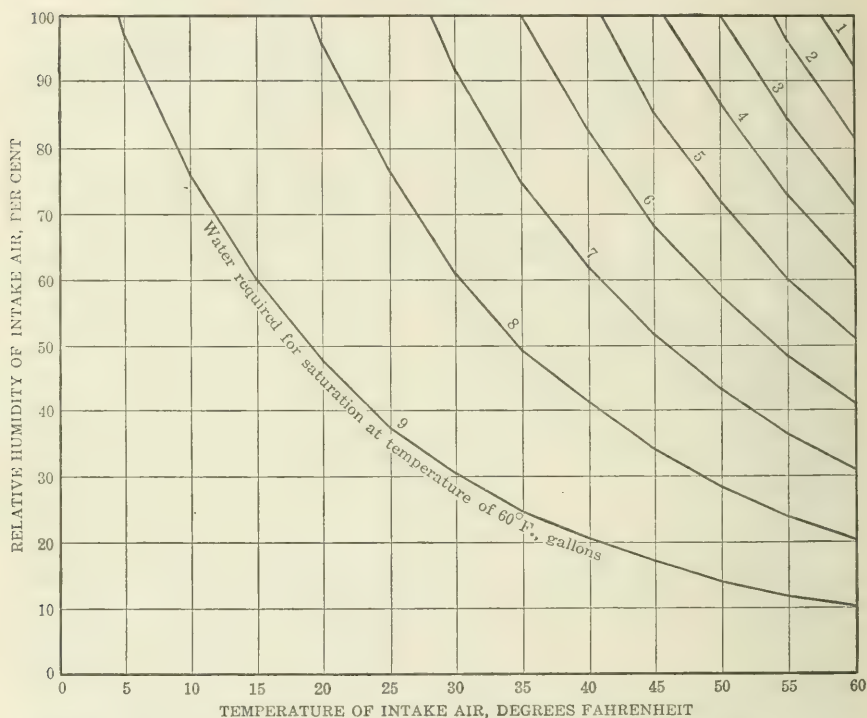


FIGURE 5.—Quantity of water necessary for different temperatures and relative humidities to cause saturation of the intake air if the temperature is raised to 60° F.

similar volume of the outside atmosphere, plus the water vapor, entering the air from the steam. For certain temperatures and relative humidities of the outside air, this quantity of moisture will give 100 per cent relative humidity at the temperature of the return; often additional water must be supplied. This additional water may conveniently be added in the form of steam, if steam is used for preheating the air, or it may be introduced into the shaft by sprays. In many mines this additional moisture may be obtained naturally from the water falling down the shaft.

Table 13, which follows, shows different temperatures and relative humidities, the amount of water in the outside air, the quantity of steam required to raise the temperature of the intake to 60° F., and the water that must be supplied to produce 100 per cent relative humidity at 60° F.

TABLE 13. *Data on premoistening 100,000 cubic feet of intake air.*

Temperature of outside air.	Water for steam necessary to raise temperature to 60° F.	Additional water required for saturation.	Relative humidity outside air.							
			30 per cent.		40 per cent.		50 per cent.		60 per cent.	
			Water in outside air.	Additional water required for saturation.	Water in outside air.	Additional water required for saturation.	Water in outside air.	Additional water required for saturation.	Water in outside air.	Additional water required for saturation.
° F.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.
0	13.13	.....	0.247	.....	0.329	.....	0.412	.....	0.494	.....
10	10.72	.....	.399	.....	.846	.....	.665	.....	.797	.....
20	8.39	1.453	.634	0.819	.846	0.607	1.057	0.396	1.268	0.185
30	6.16	3.683	.994	2.687	1.325	2.358	1.656	2.027	1.987	1.696
40	4.02	5.823	1.463	4.360	1.951	3.872	2.439	3.384	2.927	2.896
50	1.97	7.873	2.094	5.779	2.792	5.081	3.490	4.383	4.187	3.686
60	.....	9.843	2.953	6.890	3.937	5.906	4.922	4.921	5.906	3.937
70	.....	9.843	4.106	5.737	5.474	4.369	6.843	3.000	8.212	1.631
80	.....	9.843	5.633	4.210	7.510	2.333	9.388	.455	11.266	.....

Temperature of outside air.	Water for steam necessary to raise temperature to 60° F.	Additional water required for saturation.	Relative humidity outside air.							
			70 per cent.		80 per cent.		90 per cent.		100 per cent.	
			Water in outside air.	Additional water required for saturation.	Water in outside air.	Additional water required for saturation.	Water in outside air.	Additional water required for saturation.	Water in outside air.	Additional water required for saturation.
° F.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.	Galls.
0	13.13	.....	0.576	.....	0.658	.....	0.741	.....	0.823	.....
10	10.72	.....	.930	.....	1.063	.....	1.196	.....	1.329	.....
20	8.39	1.453	1.480	.....	1.691	.....	1.903	.....	2.114	.....
30	6.16	3.683	2.318	1.265	2.650	1.033	2.981	.722	3.312	0.371
40	4.02	5.823	3.451	2.408	3.902	1.921	4.390	1.433	4.878	.945
50	1.97	7.873	4.885	2.988	5.583	2.290	6.281	1.592	6.979	.894
60	.....	9.843	6.890	2.953	7.874	1.969	8.859	.984	9.843	.....
70	.....	9.843	9.580	.263	10.949	.....	12.317	.....	13.686	.....
80	.....	9.843	13.143	.....	15.021	.....	16.989	.....	18.776	.....

Figure 6, based on the calculations presented in Table 13, shows for different temperatures and relative humidities of 100,000 cubic feet of outside air, both the sum of the water in the outside air plus that in the steam required to heat the air to 60° F., and the additional water necessary for saturation at 60° F.

EXAMPLES SHOWING USE OF TABLES.

The following examples will illustrate the use of Tables 12 and 13:

1. Assume the temperature of the return air to be 60°; the temperature of the intake air to be 20°; the relative humidity of the intake air to be 40 per cent; and the quantity of air per minute to be 100,000 cubic feet. The tables show that the water in the steam required to raise the temperature will be 8.39 gallons per minute; that the horsepower necessary to furnish the steam will be 140 horse-

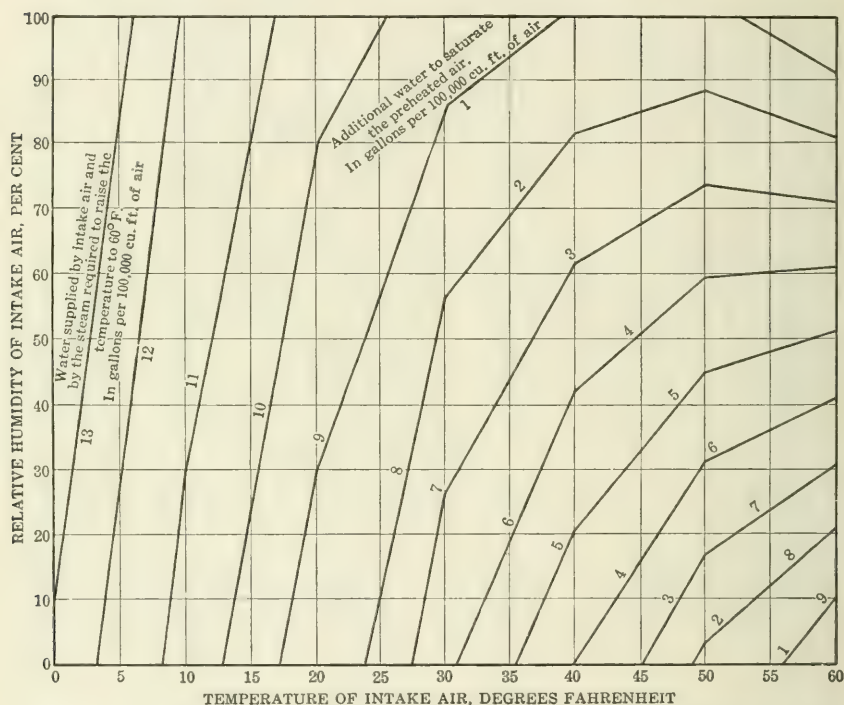


FIGURE 6.—Curves showing variation in quantity of water needed to saturate different 100,000 cubic-foot volumes of air of different relative humidities and temperatures.

power; that the coal necessary to furnish the steam will be 5.0 tons per 24 hours; and that the additional water necessary for saturation will be 0.607 gallon.

2. Assume the temperature of the return air to be 60°; the temperature of the intake air to be 10°; the relative humidity of the intake air to be 85 per cent; and the quantity of air per minute to be 50,000 cubic feet. The tables show that the water in the steam required to raise the temperature will be 5.36 gallons [$\frac{1}{2}$ (10.72)]; that the horsepower necessary to furnish the steam will be 89.5 horsepower [$\frac{1}{2}$ (179)]; that the coal necessary to furnish the steam will be

3.2 tons per 24 hours [$\frac{1}{2}$ (6.4)]; and that the additional water necessary for saturation will be 0.

3. Assume the temperature of the return air to be 60°; the temperature of the intake air to be 60°; the relative humidity of the intake air to be 70 per cent; and the quantity of air per minute to be 75,000 cubic feet. The tables show that the water in the steam required to raise the temperature will be 0; that the horsepower necessary to furnish the steam will be 0; that the coal necessary to furnish the steam will be 0; and that the additional water required for saturation will be 2.215 gallons per minute [$\frac{3}{4}$ (2.953)].

METHOD OF INTRODUCING STEAM FOR HUMIDIFICATION.

The time may come when thermostats will be used for controlling the introduction of steam into mines to raise the temperature of the intake air. At present no automatic mechanism has been applied for this purpose.

A convenient arrangement may be provided at any mine by installing at the intake a series of steam pipes, each controlled by a valve and each of a diameter calculated to permit the outflow of steam in quantities per minute sufficient to raise a given number of degrees the temperature of the intake air. The successful use of this device involves a knowledge of the volume of the ventilating current in cubic feet per minute, of the initial gage pressure of the steam in pounds per square inch, and of the temperature interval at which the device will act.

EXAMPLE AND CONVENIENT TABLES.

The use of this method of control may be illustrated by the following example: Assume that the volume of the ventilating current delivered by the fan is 100,000 cubic feet per minute, that the initial gage pressure of the steam is 100.3 pounds per square inch, and that it is desired to control the temperature of the intake air within a range of 6° F. It is then necessary to arrange a series of pipes that will control the outflow of steam required to heat the intake air to 60° F. from any temperature of the outside air. At the gage pressure of 100.3 pounds per square inch, the discharge per square inch of orifice, according to Table 14 following, will be 11.83 gallons per minute. The internal sectional areas of different sizes of standard pipes are given in Table 15 following. From these tables it is possible to arrange the following schedule for the problem under consideration.

Typical mine schedule for control of steam introduction.

Temperature of the out- side air.	Required temperature raise.	Pipes required to be opened.		Water per minute in steam discharge.
		Number.	Size.	
° F.	° F.		Inches.	Gallons.
54	6	1	1 1/4	1.23
48	12	1	3/8	2.35
42	18	1	1 1/4	3.46
36	24	2	3/8	4.52
30	30	1	3/4	6.31
23	37	1	1 1/4	7.54
17	44	1	3/4	8.57
11	50	1	1 1/4	9.89
5	56	1	3/4	10.83
-1	62	2	3/8	12.06
-7	68	1	1 1/4	13.09
-13	74	1	3/4	14.32

The above schedule indicates that five pipes will be required for the discharge of the steam, as follows: One $\frac{1}{4}$ -inch pipe, three $\frac{3}{8}$ -inch pipes, and one $\frac{3}{4}$ -inch pipe.

TABLE 14.—*Outflow of steam into atmosphere.*^a

Gage pressure per square inch.		Discharge per square inch of orifice per minute.	
Pounds.	Gallons.	Pounds.	Gallons.
35.3	5.28	100.3	11.83
45.3	6.29	120.3	13.85
55.3	7.31	140.3	15.82
60.3	7.82	150.3	16.82
75.3	9.33	200.3	21.75
85.3	10.34		

^a From Kent's mechanical engineers' handbook.

TABLE 15.—*Dimensions of standard pipe.*^a

Size.	Internal sectional area.	Size.	Internal sectional area.
Inches.	Sq. inches.	Inches.	Sq. inches.
$\frac{1}{8}$	0.057	$1\frac{1}{2}$	1.456
$\frac{1}{4}$	.104	$1\frac{3}{4}$	2.006
$\frac{3}{8}$	.191	2	2.356
$\frac{1}{2}$	.304	$2\frac{1}{2}$	4.788
$\frac{5}{8}$	.533	3	7.393
1	.864		

^a From Briggs's standard.

In the practical use of the method of steam introduction outlined above a "top man" should be detailed to make daily two or three thermometer readings of the temperature of the outside air and to open the valves of the steam pipes designated on the particular schedule in effect at the mine.

The above outline of the use of steam humidification is based on the fact that in many mines there is sufficient moisture to keep the dust damp, provided the ventilating currents are prevented from removing the moisture naturally present. Therefore the suggestion has been made that the temperature of the intake air be raised to that of the return. If a condition of extreme dryness makes it necessary to have an active sprinkling take place in the mine, the intake air can be heated slightly above the temperature of the return; and for every degree that 100,000 cubic feet per minute of intake air at 100 per cent relative humidity is heated higher than the return approximately 500 gallons of water will be deposited in 24 hours throughout the mine on ribs, roof, and floor. This deposition of moisture is probably made throughout the mine because of the gradual drop in the fan pressure on the air, the reduction in pressure causing a lowering of temperature and a consequent deposition of moisture.

COST OF USING STEAM.

The cost of using live steam would be about 44 cents per 1,000 gallons of water evaporated under the conditions observed, as compared with 60 cents for the methods calling for the use of hose, and \$1 for the water-car method. Exhaust steam from the fan and other engines would be used at most mines to furnish the greater part of the heat and moisture required properly to humidify the intake air, and live steam would be installed and used to bring about the desired control and adjustment. The combined use of exhaust and live steam under proper control would present the most economical, efficient, and practical method for mine humidification under the conditions that prevail in Illinois.

In mines where the volume of the ventilating current is very large and the quantity of steam required to humidify the intake air would be excessive, advantage may be taken of the heat radiated from the surfaces of the entries by conducting the steam in pipes a distance of a thousand or more feet into the mine before allowing it to exhaust into the intake air. Reference has already been made to the large quantity of heat that the ribs will yield to the air currents, and the possibility of practical utilization of this heat is apparent.

METHODS OF HUMIDIFICATION IN HOT WEATHER.

The above discussion relates to humidifying mine air during the colder months of the year. There are, however, some mines in which the heat of the intake air during the summer months causes heavy falls, due to the expansion of friable roofs, and in which it would be desirable to lower the temperature of the intake air when it is over 10° higher than that of the return air.

In some mines, during the hot weather, cakes of ice are strewn along the intake air courses to lower the temperature of the intake air. This method is expensive and not as efficient as the one described below.

Table 9 indicates that the average temperature of the return air of a room-and-pillar mine is 63.85° F. Table 7 shows that the average temperature of the outside air during the night is at no time over 10° F. higher than that of the return air, but that at 2 o'clock in the afternoon the average temperature of the outside air exceeds by more than 10° F. the mine temperature during June, July, August, and September. During these four months the relative humidity of the outside air (Table 8) at 4 a. m. is 86 per cent, and at 2 p. m. is 52 per cent. These figures make it evident that if water be sprayed into the intake shaft during summer the latent heat of evaporation will reduce the daytime temperature of the intake air.

Figure 7 shows the drop in the temperature of different volumes of air caused by the evaporation of 1 gallon of water.

The practical method of applying evaporation is to arrange a series of spray nozzles of known capacity at the top of the intake shaft. The smaller the particles of water delivered by the nozzles the more rapid will be the evaporation of the water. During the daytime of clear days in hot weather a sufficient number of these nozzles should be operating to give the desired drop in temperature to the known volume of the ventilating current. Care should be exercised not to reduce the intake temperature below that of the return, in order that the air currents may not rob moisture from the mine workings.

GENERAL CONCLUSIONS.

The fact that dry bituminous coal dust will explode under certain conditions has been proved both by the experience of the past and by laboratory tests and is now generally admitted by all coal men.

That coal dust may be rendered inert by the proper application of moisture has been shown both by laboratory tests and by the absence of explosions at mines in which moisture is present in the proper proportion to the quantity of dust produced.

The result of the investigation in Illinois of the humidity of mine air leads to the belief that steam may be applied to the intake air

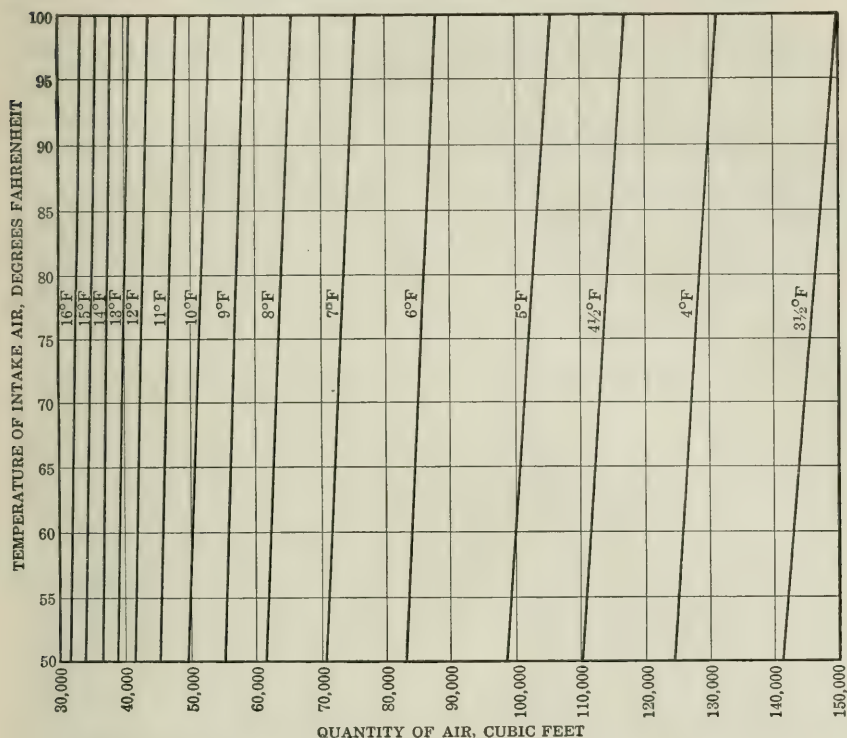


FIGURE 7.—Curves showing influence on temperature of different volumes of air caused by evaporation of 1 gallon of water.

in such a way as to offer the most economical and efficient method of dampening coal dust.

PUBLICATIONS ON MINE ACCIDENTS AND METHODS OF MINING.

A limited supply of the following publications of the Bureau of Mines is available for free distribution. Requests for all publications can not be granted, and to insure equitable distribution applicants should limit their selection to publications that may be of especial interest to them. Requests for publications should be addressed to the Director, Bureau of Mines, Washington, D. C.

BULLETIN 10. The use of permissible explosives, by J. J. Rutledge and Clarence Hall. 1912. 34 pp., 5 pls., 4 figs.

BULLETIN 17. A primer on explosives for coal miners, by C. E. Munroe and Clarence Hall. 61 pp., 10 pls., 12 figs. Reprint of United States Geological Survey Bulletin 423.

BULLETIN 20. The explosibility of coal dust, by G. S. Rice, with chapters by J. C. W. Frazer, Axel Larsen, Frank Haas, and Carl Scholz. 204 pp., 14 pls., 28 figs. Reprint of United States Geological Survey Bulletin 425.

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